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1. Introduction

Imperfect competition is a major concern in welfare analysis as it reduces consumer surplus and may erode entry barriers to new firms restricting their access to markets and thus, reducing production overall. Given that the manufacturing industry is very important to consumers as it is used to satisfy their primary needs, many studies have been carried out focusing on the market conditions across the OECD economies (Badinger, 2007; Christopoulou and Vermeulen, 2012; Afonso and Costa, 2013; Polemis and Fotis, 2016). The main argument is that rising market power in different sectors across the industry can be reflected by the price-cost margin as any gap between the selling price and the cost of production enhance this particular outcome. If firms can set the price level above the cost of production, then consumer surplus is exploited and social welfare is reduced[1]. Consequently, the level of input factor demand will also be influenced resulting in inefficient resource allocation.

The main aim of this study is to investigate the pricing decisions of 19 EU manufacturing industries disaggregated into 10 2-digit NACE Rev. 2 sectors in order to estimate the dynamics of the price-cost margin over 1995-2014. The markup ratio is calculated according to the formulations of De Loecker and Warzynski (2012) and De Loecker and Eeckhout (2017) by taking into account the interactions between output and input factors. As the markup ratio reflects a degree of market power, the estimated values will suggest whether the constituent industries operate under imperfect competitive conduct.

This study contributes to the literature of industrial organisation as it estimates the degree of imperfect competitive across of the constituent EU manufacturing industries. The markup ratio reflects the degree of competitive conduct and thus, the exercise of market power

[1] Rotemberg and Saloner (1986) argued that firms may start price wars over periods of expansion in order to attract customers and thus, increase their market share. For this reason, prices may be higher over times of recession as firms tend to invest less in market share to minimise profit losses (Chevalier and Scharfstein, 1995, 1996). Nevertheless, price wars may also occur over downturns as firms intend to secure their revenue given their access to information about their competitors' liquidity constraints.

on the selling price. Subsequently, those decisions are investigated by employing important contributors to pricing decisions, such as the degree of liquidity constraints (Raddatz, 2006) [2], export-orientation (Görg and Warzynski, 2003) and the degree of productivity (Baqaee and Farhi, 2007) when proxy variables of government regulation and industrial size are taken into account. It is expected that the aforementioned factors will have a significant effect on the markup ratio and thus, on the pricing decisions of the EU manufacturing industries. To this end, the aforementioned relationship is tested by employing a VAR framework that takes into account the presence of various issues emerging in the dataset. For this reason, this study complements the literature of imperfect competition by developing an econometric analysis that provides robust results.

This paper is organised as follows: Section 2 provides an overview of the empirical studies on the price-cost margin; section 3 develops the underlying methodology and the estimation process; section 4 presents the empirical results and discussion of pricing decisions; and section 5 offers a conclusion.

2. Theoretical and Empirical Underpinnings

The investigation of pricing decisions across various economies has been conducted over the years developing various techniques of estimating the value of the price-cost margin. The contribution of Hall (1988) utilises the assumption that the price level is equal to the marginal cost of production under perfect competition. However, given that the marginal cost of production is very difficult to observe, Hall showed that the nominal growth rate of the Solow residual is independent on the nominal growth rate of capital productivity. This implies that the price-cost margin can be estimated without directly observing the value of marginal cost.

[2] Bottasso and Sembenelli (2001) and Hoberg and Phillips (2010) show how financial constraints affect pricing decisions and particularly, how firms with higher liquidity constraints are more likely to lower their prices in order to increase their revenue.

Subsequently, Roeger (1995) extended this framework by providing an unbiased market power estimator reflecting the dynamics of value added and input factors. Therefore, the markup ratio is expressed as the difference between the growth rate of value added and the growth rate of production inputs.

A different formulation of the price-cost margin has been developed by De Loecker and Warzynski (2012) that controls for unobserved productivity in the calculation of the output elasticity of an input factor. This approach is based on particular behavioural assumptions allowing flexible production technologies and the accommodation of dynamic input factors. De Loecker and Eeckhout (2017) also highlight the importance of incorporating the factor of unobservable productivity in the markup ratio but they also correct measurement errors in sales which may lead to biased results. According to this formulation, significantly positive price-cost margins were identified for the Slovenian and US manufacturing industries reflecting an increasing trend over the years. In particular, it is found that the US manufacturing markup is on average around 67%, reflecting the overpricing decisions of the industry. Strategic decisions are influenced by factors such as human capital or the labour and capital share in the production process that have increased the markup ratio over the years[3].

Additional studies provide similar results for the pricing decisions of the manufacturing industry. Martins et al. (1996) estimated the persistence of positive price-cost margins across 14 OECD manufacturing industries, thus supporting the presence of imperfect competition. Badinger (2007) identified an imperfect competitive structure reflected by positive markups across 11 OECD industries over 1995-2000 suggesting that more integrated markets charge lower markups and experience higher productivity. Molnár and Bottini (2010) investigated the presence of market power in several EU manufacturing and service industries over 1993-2006.

[3] De Loecker and Eeckhout (2017) do not find a strong pattern across industries; however, smaller firms tend to charge higher markups influenced by the size of the industry they operate in.

The findings show that competition is more persistent in the sectors of the Scandinavian countries (excluding Sweden) and the United Kingdom, and lower in the sectors of Central European countries (see Polemis, 2014). Christopoulou and Vermeulen (2012) also provided evidence in favour of imperfect competition across the industries of several European countries, concluding that the manufacturing industry on average is more competitive compared to the service industry[4].

Similar results were obtained by studies focused on export-oriented firms and sectors. Görg and Warzynski (2003) and Amountzias (2018) estimated the markup dynamics of UK exporting firms and concluded that they tend to charge a higher markup ratio compared to non-exporting firms even under the pressure of foreign competition. This implies that exporting firms can charge different selling prices across different markets and consequently, they can exploit their power in some markets by charging a higher markup ratio to acquire higher profits. For this reason, international trade and input factors appear to have a significant effect on pricing decisions.

De Loecker (2007) and De Loecker and Warzynski (2012) argued on the same line of reasoning that Slovenian exporters tend to charge a higher markup ratio compared to less export-oriented firms as a result of international trade. In addition, export-oriented firms tend to be more productive than their domestic counterparts and they enjoy higher productivity gains when they are exporting towards high income economies. This argument validates the study of Nicoletti and Scrapetta (2005) who mentioned that firms operating in highly competitive markets tend to increase their investment and productivity levels to keep up with their

[4] However, Polemis and Fotis (2016) found no evidence of imperfect competition in the majority of manufacturing and service sectors of the Eurozone, the US and Japan. The main factor for this outcome lies on the openness of the sectors to international markets and deregulation resulting in competitive pricing strategies. Similar results are reported by Bottasso and Sembenneli (2001), Konings et al. (2005), Görg and Warzynski (2006) and Feenstra and Weinstein (2010) arguing that markups are reduced when firms are exposed to highly competitive conditions.

competitors and extend their market share. Bourlès et al. (2013) also support this outcome highlighting the fact that anti-competitive regulations tend to decrease multifactor productivity and thus, force firms to be less investment-oriented and charge a higher markup.

An additional factor contributing to the formulation of pricing strategies corresponds to the degree of available liquidity accessed by firms as any funding invested in the production process may be reflected on the price-cost margin. Chevalier and Scharfstein (1995, 1996) argued that markups tend to be counter-cyclical when firms face financial constraints. This shows that lower price levels are charged in order to build market share and thus, increase revenue. Campello (2003) provided similar evidence suggesting that markups are higher in industries where firms face high levels of debt resulting in counter-cyclical behaviour. This also implies that firms heavily relying on external funding are more likely to increase their markup ratio by sacrificing part of their market share in order to face any potential negative shocks in demand. Lane (2012) and Braun and Raddatz (2016) also argued that firms with lower financial constraints will tend to charge a higher markup ratio as they can use their available liquidity reserves to substitute any potential loss in consumer demand as a result of a higher selling price. Therefore, firms operating in an intensive competitive environment and facing higher liquidity constraints tend to be more pro-cyclical as price wars intensify over periods of low consumer demand[5].

3. Methodology

3.1. Model formulation and data selection

The markup ratio is estimated according to the formulation developed by De Loecker and Warzynski (2012) and De Loecker and Eeckhout (2017). It reflects the difference between

[5] Green and Porter (1984) and Rotemberg and Saloner (1986) contradict this argument supporting that price wars usually emerge over expansion periods because firms intend to increase their market share.

value added and the cost of production when the price elasticity of inputs is taken into account. The formulation of this ratio is presented in appendix. To this end, as the markup ratio is estimated across the constituent EU manufacturing industries, three major factors are taken into account in order to test their influence on the pricing decisions of the EU manufacturing sectors. In particular, the effects of liquidity constraints, exports and productivity are included in the current analysis as their influence is quite significant on pricing decisions (Bloch and Olive, 2003; Afonso and Costa, 2013; Braun and Raddatz, 2016; Amountzias, 2018). The main regression is provided by

$$\mu_{it} = \mu(fr_{it}, xp_{it}, pr_{it}, rg_{it}, vl_{it}) \quad (1)$$

where fr is a proxy of financial underdevelopment for each industry i, xp is the ratio of manufacturing exports as a percentage of merchandise exports, pr reflects productivity per worker expressed as gross manufacturing output over the number of workers, rg is a proxy of market (de)regulation and vl corresponds to the ratio of total value added over GDP for each manufacturing industry i. All variables are expressed in logarithms in order to obtain the elasticity values over the estimation process.

[Table 1]

The dataset consists of 19 EU manufacturing industries disaggregated into 10 2-digit NACE Rev.2 sectors over 1995-2014. In particular, the current dataset intends to extend the empirical insights of Afonso and Costa (2013), Apergis and Polemis (2015), Apergis et al. (2016) and Polemis and Fotis (2016) and explore the markup dynamics in selected countries across the European Union[6]. Subsequently, the effects of liquidity constraints, exports and

[6] The constituent countries refer to Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxemburg, Netherlands, Portugal, Slovak Republic, Slovenia, Spain, Sweden and UK.

productivity will be tested on the pricing decisions of the EU manufacturing industries when the factors of regulation and industrial value are taken into account.

The main assumption of the model is that government intervention is the only external factor controlling for pricing decisions as any other policy factors are excluded. Moreover, the influence of international markets, as well as non-EU regulations are not taken into account suggesting that only EU-registered firms were included in the collection of industrial data. Finally, firm-behaviour and its effect on the industrial markup ratio is not taken into account due to data limitations. This implies that the model is quite aggregated as the behaviour of medium size firms may not be reflected in the aggregate markup ratio given that it usually represents the pricing decisions of the dominant firms.

For this reason, the underlying model has two particular objectives. Initially, the degree of imperfect competitive conduct will be identified in order to observe the pricing strategies of the constituent industries. Subsequently, those decisions will be investigated by employing important contributors to the markup ratio, such as the degree of liquidity constraints (Raddatz, 2006), export-orientation (Görg and Warzynski, 2003) and the degree of productivity (Baqaee and Farhi, 2007) when the proxies of government regulation and the size of the industry are taken into account.

The model formulation captured by equation (1) reflects the pricing decisions of the constituent manufacturing sectors by taking into account various market factors. As the main intention of this study is to provide an interpretation of how pricing strategies are set according to competitive and financial forces, indicators of regulations, productivity, export orientation and industrial size were taken into account to investigate their effect on the markup dynamics. The theoretical foundations of equation (1) lie on the empirical work of Raddatz (2006) and Braun and Raddatz (2016) by attempting to model the effects of financial factors on the price-cost margin. The main argument raised by those studies is that industries with different structural characteristics, such as concentration and liquidity constraints, may exercise their power on the markup ratio as they control a significant percentage market share and they are not bound by funding restrictions. To this end, the role of institutions and regulators can shape market conditions and prevent large firms from exercising their power on consumers through the final selling price level.

Nevertheless, as many limitations emerged in data collection, the current model is not able to investigate the full extent of the insights of Braun and Raddatz (2016) across the 19 EU manufacturing industries. Therefore, the best alternative was to employ similar proxies that can reflect financial and market decisions undertaken by sectors. In particular, equation (1) consists of two sets of variables: regulatory proxies and production indicators. The former set captures the financial and market regulations imposed by relevant institutions, while the latter set reflects the productions decisions of firms operating under the present regulatory framework. Moreover, given that the *OECD statistics,* the *World Bank* and the *Bank of International Settlements (BIS)* databases provided complete data up to the 2-digit sectorial level, equation (1) takes into account only 10 2-digit NACE Rev.2 sectors per country. For this reason, the main limitations of the present model are the exclusion of a liquidity constraints indicator that could complement the financial development proxy, as well as a detailed concentration ratio that could reflect competitive conditions on a firm-level analysis. Consequently, the main empirical insights are focused on the effects of regulations and production decisions and how they tend to shape the dynamics of the markup ratio.

The price-cost margin is estimated by employing equations (A1)-(A7) in the appendix. In particular, the data for output, variable and fixed costs have been obtained by the *OECD statistics* and they include the measures of gross output, intermediate inputs, labour compensation and gross capital formation. They have been used in the production function in order to obtain output elasticity with respect to variable inputs. Subsequently, the final markup value is estimated by employing total value added observations suggesting that the only variable input included in the markup formulation is labour. Therefore, the cost of intermediate inputs is omitted from equation (A7)[7].

The proxy of financial underdevelopment is formulated according to Braun and Raddatz (2016) by taking into account the available credit level to the private sector of each economy. The credit to GDP ratio has been obtained by the *World Bank* and the *Bank of International Settlements (BIS)* databases. The main rationale for the inclusion of this measure is to investigate how restricted access to credit influences the price-cost margin dynamics as it is one of the main sources of investment. Braun and Raddatz (2016) suggest that financial underdevelopment leads to countercyclical markups, thus making firms more competitive over expansion periods. However, Amountzias (2018) showed that higher access to credit may have either a positive or negative effect on pricing decisions over different periods according to the conditions of the aggregate economy. Overall, credit provision is expected to have a significant effect on markups and therefore, it is included in equation (1).

The intensity of exports of each industry individually is expressed as the ratio of manufacturing exports over merchandise exports obtained by the *OECD statistics.* Görg and Warzynski (2003) supported that export-oriented firms tend to charge a higher price-cost margin due to the competitive advantage enjoyed by product differentiation. In particular, revenue obtained in international markets can be used in the domestic market to increase production funding and thus, increase the competitive advantage over non-exporting firms. This argument is supported by Bernard et al. (2003), De Loecker and Warzynski (2012) and

[7] A similar approach is followed by Rezitis and Kalantzi (2012) as total value added data is used in the markup formulation.

Amountzias (2018) as they provided evidence showing that exporters charge on average a higher markup ratio compared to non-exporting firms.

The indicator of productivity is expressed as gross manufacturing output over the number of employees in each industry. The observations were obtained by the *OECD statistics*. According to Nicoletti and Scarpetta (2003, 2006) productivity is an essential factor for the development of any industry and thus, regulations in favour of liberalisation and promotion of the private sector enhance production overall. However, Baqaee and Farhi (2017) argued that higher markups in the US economy are followed by a slowdown in productivity, particularly due to the acquisition of market power. For this reason, the absence of sufficient regulations may provide the opportunity to some firms to charge a price level according to imperfect competitive conduct.

This means that a control factor for productivity is the degree of regulation in the economy promoting the presence of the private sector. This indicator was obtained by *The Worldwide Governance Indicators* database and its values range between -2.5 and 2.5 with ascending order of government regulation. It reflects the efforts of governments to formulate and implement policies and regulations that promote private sector development in the market of products, thus enhancing market liberalisation. The final control factor is the value of each manufacturing industry to GDP, expressed as the ratio of total value added over gross aggregate output. It is employed as a proxy for the size of the manufacturing industry over the years compared to the size of the aggregate economy[8]. Even if the value to GDP ratio is quite stable over the years across the constituent manufacturing industries, it is rather important to include it into equation (1) as an industrial size indicator.

[8] This particular ratio is formulated by including total value added data of the constituent 2-digit sectors. More suiTable indicators refer to the Herfindahl-Hirschman index, the concentration ratio or the size of the four largest firms in the sector (Domowitz et al., 1988; Konings et al., 2005; Olive, 2008; Bellone et al., 2016). However, given firm-level data limitation, the value to GDP indicator for the whole manufacturing industry is selected.

3.2. VAR framework

As the panel set of this study consists of 19 EU manufacturing industries, it is expected that some form of cross-section dependence will emerge in equation (1). For this reason, Pesaran's (2004) cross-section dependence tests (LM and scaled tests) are employed to investigate the presence of contemporaneous correlation. Both tests take into account the average value of all pair-wise correlation coefficients of the OLS residuals estimated by the Augmented Dickey-Fuller (ADF) regression of each variable. The null hypothesis reflects the absence of such correlation and thus, a simple pooled least squares model can be estimated. The alternative hypothesis suggests the presence of contemporaneous correlation, meaning that alternative estimation techniques must be applied[9].

Subsequently, the integration order of the constituent panel series has to be tested in order to decide whether a panel Vector Autoregression (VAR) framework must be applied. In particular, the unit root tests applied on the variables of equation (1) correspond to Pesaran's (2007) cross-section ADF tests (CADF) where the initial ADF regression is augmented by the cross-section average values of lagged levels and first differences. This transformation accounts for the presence of cross-section dependence across the panel set and thus, it provides more robust results compared to the simple ADF regression. If at least one of the series is found to be non-stationary at levels, the presence of cointegration must be tested in order to explore the presence of a long-run relationship amongst the panel series.

Therefore, Westerlund's (2008) cointegration test is applied on equation (1) which takes into account the presence of cross-section dependence by providing the group and the panel Durbin-Hausman test statistics. The null hypothesis of both statistics refers to the absence of a long-run relationship. This approach does not require prior knowledge about the order of

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[9] Two of the most popular techniques refer to the random and fixed effects model (Baltagi, 2001). However, if the panel series are first order integrated, then a panel VAR framework must be taken into account.

integration of the constituent variables. The presence of cross-section dependence is captured by a factor model in which the residuals are obtained by common unobservable factors across the constituent industries (Auteri and Constantini, 2010). Moreover, Pedroni's (2004) statistics are employed in order to support the outcome provided by the group and the panel Durbin-Hausman test statistics[10]. Finally, the presence of long-run stability is tested in order to investigate whether any structural breaks emerge in the sample. The CUSUM and CUSUM squares tests are employed developed by Page (1954) and Khan (1978) along with the structural stability tests proposed by Andrews (1993), Andrews and Ploberger (1994) and Bai and Perron (2003). The main purpose of those tests is to identify the presence of any break emerging over the underlying period which may reduce the accuracy and validity of the estimated values.

If the presence of all the aforementioned issues is confirmed, a panel Vector Error Correction model will be formulated in order to capture the long-run relationship between the markup ratio and liquidity constraints, export-orientation and productivity. However, given the presence of contemporaneous correlation, a pooled least squares estimator will result in inefficient inferences. The most suitable estimator refers to the Common Correlated Effects (CCE) estimator proposed by Pesaran (2006). The formulation process is similar to the one of the CADF unit root test, where the main regression is augmented by the cross-section average values of the countries over the 20 years of the sample. This approach allows individual specific error terms to be heteroskedastic and serially correlated. For this reason, the CCE estimator is preferable compared to the Fully Modified OLS (FMOLS) or the Dynamic OLS (DOLS) estimators as they result in incorrect inferences under the presence of cross-section dependence (Phillips and Sul, 2003).

[10] It is worth mentioning that Pedroni's (2004) test statistics do not take into account the presence of cross-section dependence, thus assuming that the panel series are not subject to contemporaneous correlation.

Moreover, alternative estimation techniques can be taken into account, such as the Generalised Method of Moments (GMM) employed by several studies (Klette, 1999; Wooldridge, 2009; De Loecker and Warzynski, 2012). The GMM technique employs a list of instruments taking into account the presence of endogeneity when any form of correlation emerges between the dependent variable and at least one of the explanatory variables. Consequently, it is an advantageous estimator as it eliminates the problem of inconsistency providing robust results.

As presented by Hansen (1982) and Arellano and Bover (1995), in conjunction to endogeneity, the weighted matrix can be formulated accordingly in order to take into account the presence of serial correlation and heteroskedasticity (Newey and West, 1987, 1994). For this reason, it provides a credible alternative for checking the robustness of the CCE results that fail to reflect the presence of endogeneity. To this end, both estimators suffer from omissions but if they are tested together they can provided robust results and conclude whether contemporaneous correlation and endogeneity significantly shape the final estimates.

The final step of this process identifies the short-run effects amongst the variables by employing particular causality tests. The non-Granger causality test developed by Dumitrescu and Hurlin (2012) is employed by taking into account stationary series using the Z-bar statistic for the fixed coefficients of the constituent variables under a panel VAR framework. The null hypothesis indicates the absence of causality in any cross-section of the panel set obtained by the Wald statistic. In particular, the Wald statistic is obtained for each cross-section and subsequently, the average value of those statistics is calculated[11]. The main advantage of this approach is the assumption that coefficients are heterogeneous across the cross-sections[12].

[11] Dumitrescu and Hurlin (2012) argued that this value converges to normal distribution under the null hypothesis when *N* and *T* tend to infinity.
[12] This assumption however, is not included in Granger's (1969) causality test.

Moreover, the Impulse Responses Functions are presented to test the responsiveness of the markup ratio to a standard deviation shock caused by the remaining variables of the model.

Overall, the aforementioned process is applied in the 19 EU manufacturing industries in order to explore how markup dynamics are influenced by the effects of liquidity constraints, export orientation and productivity. As the econometric process takes into account the presence of many issues emerging in the dataset, this model adds value in the literature of imperfect competition because it employs a VAR framework under which robust long-run results are obtained and the short-run behaviour of the constituent variables is observed. This addition differentiates the current model from the models of previous studies as they either employ a fixed or random effects model (Christopoulou and Vermoulen, 2012; Polemis, 2016) or they utilise the GMM estimator without taking into account the presence of stationary and cross-section dependence (Badinger, 2007; Braun and Raddatz, 2016; Bellone et al., 2016). Therefore, the consideration of a VAR framework under which structural stability and contemporaneous correlation are taken into account improve the robustness of the empirical results and their importance for the EU market.

4. Empirical results and discussion

The empirical process of this study takes into account two steps. The first step estimates equation (A7) for the aggregate EU manufacturing industry, each EU manufacturing industry and each constituent 2-digit level sector. The second step, utilises the industrial estimates of the previous step for each country and estimates equation (1) under a panel VAR framework. The main rationale of this process is to initially investigate the dynamics of the markup ratio in the EU area and conclude, whether the presence of imperfect competition is significant in that region.

Afonso and Costa (2013) argued that markup ratios tend to be pro-cyclical to productivity shocks and counter-cyclical to fiscal spending shocks. For this reason, the degree of regulation in markets highly affects the competitive behaviour of the participants. Polemis and Fotis (2016) provided evidence that more deregulated markets tend to be more competitive and thus, charge a lower price-cost margin to attract more customers. This rationale results in insignificant evidence of imperfect competition at least across the countries of the Eurozone. Additional studies explore the pricing decisions of the manufacturing industries in the EU countries concluding that there is evidence of imperfect competition but the price-cost margin is close to unity[13].

[Table 2]

[Figure 1]

[Figure 2]

The estimation of equation (A7) for the 19 EU countries provides significant evidence of imperfect competition. Table 2 reflects the markup ratios of the constituent 2-digit level sectors of the 19 EU manufacturing industries. The values show that in every sector, the price-cost margin is higher than unity, thus reflecting the presence of overpricing decisions which may also be an indicator of imperfect competition[14]. In particular, Ireland and Slovak Republic exhibit the highest markup ratio across the constituent industries. It is equal to 2.01 and 2 respectively showing that the selling price is approximately 100% higher than the marginal cost of production. On the other hand, Luxemburg and the UK exhibit the lowest markup ratio which is equal to 1.38 and 1.41 respectively, thus reflecting a relatively lower degree of imperfect competitive conduct. This outcome is consistent with similar studies arguing about

[13] Some of these studies refer to Belgium (Dobbelaere, 2004), Greece (Polemis, 2014; Amountzias, 2017), Ireland (Boyle, 2004), Slovenia (De Loecker, 2007), Sweden (Wilhelmsson, 2006) and the UK (Görg and Warzynski, 2003, 2006; Amountzias, 2018).

[14] Nevertheless, De Loecker and Eeckhout (2017) support that higher markup ratios may not always reflect market power. If the source of that increase is technological change that reduces variable costs but increases fixed costs, then firms will not drop the selling price as they need to generate additional revenue.

overpricing decisions and the presence of imperfect competitive conduct across the OECD economies (Martins et al., 1996; Molnár and Bottini, 2010; Christopoulou and Vermeulen; 2012).

In particular, figure 1 shows that the price-cost margin of the constituent manufacturing industries tends to increase over 1995-2014 by reaching its climax in 2007 before the eruption of the global financial crisis in 2008. This means that the markup ratio tends to be pro-cyclical as 1995-2007 was a period of expansion for the EU on average. Moreover, the lowest values are obtained over 1996 and 2009. The former value may be a result of the Single European Market (SEM) implementation completed in 1992 (European Commission, 2012). Even if there are no available estimates over 1992-1995, the falling trend over 1995-1996 could reflect this particular outcome. The latter value reflects the effects of the global financial crisis which caused a fall in aggregate demand over the following years and thus, a fall in the price-cost margin so that firms can minimise their losses in terms of market share (Ollivaud and Turner, 2015).

Figure 2 illustrates the estimated markup ratio for 4 regions within the EU categorised by regional criteria[15]. In particular, the countries of the east and south blocs appear to charge a higher markup ratio compared to the EU average, while the central bloc seems to be the most competitive. The markup dynamics provide approximately the same trend across the 4 blocs reflected by a pro-cyclical pattern: increasing markup ratios over 1995-2007 and a fall in 2009.

However, across the countries of the south EU bloc the price-cost margin appears to rapidly increase over 1999-2002 and then gradually fall. An interpretation for this pattern may lie on the introduction of the euro currency across those countries over that period[16]. As the

[15] Central EU countries correspond to Austria, Belgium, France, Germany, Luxemburg and the Netherlands. North EU countries include Denmark, Finland, Sweden and the UK. East EU countries refer to Czech Republic, Hungary, Slovak Republic and Slovenia. South EU countries are Portugal, Italy, Ireland, Greece and Spain.

[16] Portugal, Ireland, Spain and Italy joined the Eurozone in 1999 while Greece joined in 2001.

new revaluated currency resulted in higher purchasing power parity to consumers, the manufacturing firms increased the price-cost margin of their final products in order to exploit part of that surplus. The subsequent fall of the markup ratio over 2002-2006 may reflect the normalisation of the manufacturing firms' pricing decisions following the exogenous shock caused by the introduction of the new currency. This may have happened either through lower selling prices or higher input costs. To this end, there is a degree of convergence between Central and Northern Europe. Nevertheless, the markup ratio of Eastern and South Europe diverges from the EU average dynamics reflecting overpricing decisions in the domestic manufacturing industries. This outcome could be interpreted on the basis of lacking regulatory reforms and sufficient competition frameworks that restrict competitive interactions and provide power to a few firms (OECD, 2014a).

The markup ratio pattern across the EU countries also supports the findings of OECD (2014b) arguing that competition in the manufacturing industry is essential in order to minimise consumer surplus exploitation. One of the main factors that could enhance competition and reduce the costs of production is technological improvement in order to improve the efficiency of the production process. Under this rationale, firms can keep up with consumer preferences and also, consumers can purchase products under a selling price level close to the cost of production. For this reason, those incentives must be enhanced across the whole industry by undertaking the necessary decisions.

Consequently, investment decisions and deregulatory actions are the main contributors shaping the competitive conditions across the manufacturing sectors of the EU countries promoting entrepreneurial activities and innovation overall (Nicoletti and Scrapetta, 2005; OECD 2018). Various programmes such as the environmental compliance programme (OECD, 2003) and competition assessment toolkits (OECD, 2014a) have contributed to this outcome in order to eliminate inefficient barriers in the markets that restrain the economic activities of the private sector and generally, of new entrants in the industry. Moreover, the introduction of new technologies enhancing economies of scales across the manufacturing firms may also provide opportunities to the incumbent firms to expand their trading activities in the international markets by developing and promoting their products to meet the needs of international demand.

For this reason, the next step of the analysis utilises the markup ratios for each industry over 1995-2014. It tests their relationship with the degree of financial underdevelopment of the manufacturing industries, their export orientation and productivity, when the factors of market regulation and industrial size are taken into account.

[Table 3]

[Table 4]

[Table 5]

Table 3 provides the results of Pesaran's (2004) cross sectional dependence tests. Every panel series is found to be subject to contemporaneous correlation and thus, a simple panel lest squares estimator will result in incorrect inferences. For this reason, the order of integration of each series will be investigated as a panel VAR model has to be employed in the presence of unit roots. Table 4 provides significant evidence of first order integration in the panel series of equation (1), excluding the series of financial underdevelopment which is stationary at levels.

Subsequently, the presence of cointegration must be explored to check whether a long-run relationship persists amongst the constituent panel series. Pedroni's (2004) and Westerlund's (2008) tests are employed and their results are presented in Table 5. As the presence of cross sectional dependence persists in the model, the Durbin-Hausman statistics are mainly taken into account. Given that both of them are significant at least at the 5% level of significance, the presence of a long-run relationship cannot be rejected and thus, the error correction mechanism must be included in the panel VAR framework. The PP and ADF statistics also point to this particular outcome, validating the fact that the series of equation (1) are cointegrated under the presence of cross sectional dependence.

[Figure 3]

[Table 6]

Moreover, the presence of long-run stability is tested in order to investigate the presence of structural breaks emerging in the sample. Figure 3 presents the recursive estimates for each coefficient in equation (1) along with the CUSUM and CUSUM squares diagnostics that test the long-run stability of the model (Page, 1954; Khan, 1978). The results are presented in Table 6 and show that in the long-run there is no significant sign of structural breaks in the markup formulation. This outcome is also validated by the structural stability tests proposed by Andrews (1993), Andrews and Ploberger (1994) and Bai and Perron (2003) as they do not reject the null hypothesis of no breakpoints over 1995-2014.

[Table 7]

Consequently, equation (1) is estimated under the CCE estimation technique proposed by Pesaran (2006) in order to capture the presence of contemporaneous correlation. Moreover, the Fully Modified OLS (FMOLS) estimator, the Generalised Method of Moments (GMM) and the Autoregressive Distributed Lag (ARDL) techniques are employed to test the robustness of the estimates and check whether the issue of cross sectional dependence results in any significant changes across the final estimates[17].

Every estimation technique provides similar results for the effects of the explanatory variables on the markup ratio across the 19 EU manufacturing industries. The FMOLS estimator reports an insignificant value for the elasticity of the markup ratio with respect to

[17] The GMM estimator is employed in order to check whether any potential endogeneity in the model affects the final estimates (Hansen, 1982; Arellano and Bover, 1995). The ARDL model is used as a test of robustness for the CCE estimations, as suggested by Pesaran et al. (1999).

regulation and financial underdevelopment, while the GMM and the ARDL techniques report insignificant values only for the markup elasticity with respect to regulation and exports respectively. For this reason, it is evident that the presence of cross sectional dependence must be included in the estimation process as the CCE estimator provides significant results for every variable.

In particular, the price-cost margin elasticity with respect to financial underdevelopment appears to be negative and quite inelastic. This means that as the manufacturing industries struggle to get additional credit for their activities, they tend to reduce the price-cost margin in order to increase their market share and thus, their revenue. Moreover, liquidity constrained industries are expected to invest less in innovation. If innovation is limited, the quality improvement of products will also be limited and they cannot gain competitive advantage over their competitors who may be less liquidity constrained.

This outcome is supported by the findings of Bottasso and Sembenelli (2001) and Busse (2002) who argued that when firms with liquidity constraints compete intensively, it is more likely that they will follow predatory strategies and start price wars, especially over downturns. As the constituent manufacturing sectors have more access to credit acquisition, they tend to increase the price-cost margin and use that credit as a profit cushion against any market share losses when the final selling price is higher[18].

However, such findings contradict several studies arguing in favour of lower markup ratios when firms have higher access to credit (Chevalier and Scharfstein, 1995, 1996; Campello, 2003; Braun and Raddatz, 2016). Therefore, it can be concluded that the pricing decisions across the constituent EU manufacturing industries significantly depend on credit

[18] Makaew and Maksimovic (2013) also note the importance of cash flow in the production decisions of developing economies. Liquidity constraints have a significant and highly elastic effect on final output and thus, on entrepreneurial activity.

acquisition. Lower liquidity constraints tend to increase the price-cost margin because they reflect a higher selling price as a result of higher investment costs[19].

This argument is also supported by Kraemer-Eis et al. (2017) as small and medium sized manufacturing firms are very important elements of manufacture success given the inelastic nature of the products. As such firms may not always be able to get financial support for their activities, various institutions must step in and provide that funding in order to operate efficiently and thrive under a competitive market structure, usually dominated by large firms. To this end, loans to such firms have been provided by the European Investment Fund since 2013 and particularly, to firms operating in economies that faced a recessions over the last years, such as Greece, Ireland, Portugal and Spain (OECD, 2018)[20]. The importance of such lending provides the opportunity to absorb any negative shocks caused by a decline in aggregate demand and also, supply those products at an affordable selling price for customers. Therefore, liquidity constraints pose a significant threat to manufacturing production and competition and if left unchecked, it could lead to high market concentration as funding will be the main competitive advantage of large firms.

Subsequently, a secure channel of liquidity provision may also encourage firms to expand their international activities and form new supply chains. For this reason, the second element of equation (1) corresponds to the elasticity of the markup ratio with respect to exports. The main rationale of this coefficient is to investigate the pricing decisions of export-oriented industries and how they tend to set their price level. The coefficient is significant and equal to

[19] This behaviour is also consistent with the speculative motive. As firms have greater access to liquidity, they will charge a higher markup ratio to exploit consumer surplus and substitute any loss in consumer demand with available credit. For this reason, only liquidity constrained firms act according to the precautionary motive as they charge a lower price-cost margin in order to increase their market share and ultimately, their revenue (Kimball, 1991).

[20] Moreover, the Euro Area banks continue to ease the credit standards for small and medium sized firms applying for business loans. However, firms operating in the Southern European economies find it more difficult to secure a loan compared to firms operating in Central and Northern European economies (OECD, 2018).

0.21. This reflects the fact that more export-oriented sectors tend to charge a higher price-cost margin as they operate in more than one market. This outcome supports the empirical evidence of similar studies suggesting that exposure to international markets may result in market power acquisition in domestic markets due to a high degree of efficiency (Görg and Warzynski, 2003; Bernard et al., 2003; De Loecker and Warzynski, 2012). This means that generated revenue from a particular market can be invested in the economic activities of another market and thus, provide additional liquidity in the production process.

In particular, as austerity policies were implemented across the EU economies, domestic firms sought opportunities in international markets given that the euro currency became weaker relative to other currencies (Sinn, 2014; Hardiman et al., 2016). Bernard et al. (2003) supported that more efficient producers may set higher markup ratios compared to their competitors as their main tool of competition is the quality and not the price level of the final product. When firms operate in many markets, they adjust to many market characteristics and strive to efficiently utilise their gains. For this reason, export-oriented firms tend to be more productive than their domestic counterparts as various types of investment are incorporated in the production process (De Loecker, 2007; Baumers et al., 2016).

This outcome is also supported by OECD (2018) because exports significantly depend on the economic conditions surrounding international markets and thus, the pricing strategies adopted by the participants. As the economic outlook in the EU area is steadily improving, consumer confidence is restored given that aggregate demand is constantly increasing. To this end, manufacturing firms must comply with the new demand levels utilising their equipment and capacities constraints in order to effectively meet consumer preferences.

The result of the aforementioned actions undertaken by the manufacturing sectors will lead to productivity improvement expressed as output per worker. It is expected that more productive sectors tend to increase the price-cost margin because final output reflects all forms of investment (Hall, 1988). Baqaee and Farhi (2017) argued that changes in productivity involve two major components: changes in allocative efficiency and technological productivity. As the value of gross output reflects every factor utilised in the production process, including technological progress as captured by equation (A5b), the current productivity index incorporates both measures as an average value per worker.

However, an important element of productivity improvement usually reflects the competitive conditions in the market. As markets tend to be less competitive, firms may not have the incentives to invest in their production process and thus, productivity may become stagnant or even fall. Andrews et al. (2016, 2017) support that the productivity gap in the EU manufacturing industries is quite significant and increasing because there is insufficient diffusion of knowledge and technology from the leading to the lagging firms. One important factor contributing to this outcome is the presence of many administrative and regulatory barriers that put small and medium sized firms to a disadvantageous position as they need more time and funding in order to compete with the leading firms.

An additional factor complementing production performance and pricing decisions is government intervention. The regulation index employed in this study captures the promotion of market-friendly policies removing barriers to private entrepreneurial activity. The effect on the price-cost margin is found to be significant and negative. This outcome suggests that as markets become more competitive through trade liberalisation, sectors tend to reduce the markup ratio as a mean of competition (De Loecker et al, 2016). This outcome is also supported by the study of OECD (Meloni, 2010) arguing that the quality of regulatory policy can erase inefficient barriers restricting competition in the manufacturing industry. This happens by promoting incentives of intensive price competition through which market share expansion rather than consumer surplus exploitation is the main motivation of firms. To this end, regulations should be implemented in order to promote competitive actions in any industry. In conjunction with liquidity provision by financial institutions, it should also provide the opportunity to manufacturing firms to improve their technology and compete in a healthy environment in order to meet consumer demand and expand their trading activities (Xu and Byoun, 2015).

Bourlès et al. (2013) and Ollivaud and Turner (2013) argued that competitive upstream pressure tends to increase productivity in the markets as firms strive to compete for market share. Nicoletti and Scarpetta (2005) also suggested that pro-competitive reforms are expected to increase productivity and investment overall, thus leading to higher GDP per capita growth rates. Consequently, more productive sectors tend to charge a higher price-cost margin reflecting all forms of investment activity in the production process.

The last control factor in the model is the value of each manufacturing industry to GDP serving as an indicator of market value. Given the positive value presented in table 6, as the value of the industry increases over time, markup ratios tend to increase as well, reflecting a form of market power. This outcome is consistent with the findings of Konings and Vandenbussche (2005), Konings et al. (2005) and Amountzias (2018) who argued that market concentration may result in higher markup ratios across the industry. Although the current value ratio is far from providing an accurate indicator of concentration or the size of the constituent sectors, it is employed as a proxy of manufacture contribution to national output. For this reason, the only conclusion that can be drawn reflects the activities of the manufacturing industry as an aggregate entity. This suggests that as the industry's contribution to GDP becomes larger over time, the price-cost margin tends to increase as well[21].

[21] The model was re-estimated by adding time dummy variables excluding the period of the global financial crisis (2007-2010). The results remained consistently similar as the signs were the same with the ones reported in Table 6. There were small variations in the significance level but the estimates reflected the same outcome. Therefore,

[Table 8]

The aforementioned results are also validated by the short-run causality test presented by Dumitrescu and Hurlin (2012). In particular, they reflect significant causality running from all explanatory variables to the markup ratio, except from the value to GDP ratio of the manufacturing industry. Liquidity constraints are only influenced by the degree of market regulation, suggesting that competitive conditions affect the liquidity needs of sectors in the short run. Export intensity is caused by liquidity constraints and market regulation, which once again validates the arguments of Görg and Warzynski (2003) and De Loecker and Warzynski (2012) about the role of international trade and exposure to international markets.

The indicator of productivity is only caused by the value of the manufacturing industry to GDP supporting the argument that larger industries tend to contribute more resources to the production process by enhancing productivity overall. Therefore, in the long-run, higher productivity will increase the price-cost margin by reflecting all these forms of investment. Market regulation depends on the pricing decisions of the sectors, as well as their access to liquidity. As these parameters may reflect competitive conduct, regulatory decisions are formed according to their short-run dynamics. Finally, the value of the manufacturing industry is caused by every independent variable except from regulation which once again shows that market conditions influencing competitive conduct have a significant effect on the value added of the whole industry.

[Figure 4]

Figure 4 reflects the Impulse Response Functions for the aggregate manufacturing industry across the 19 countries of the sample. In particular, the diagram shows the

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this particular shock did not cause any significant variations to the dynamics of the constituent series over 1995-2014.

responsiveness of each variable in the Vector Error Correction model to each own standard deviation shock and to the shock of other variables. Financial underdevelopment appears to have a negative effect on the markup ratio over 8 periods; however, that effect is not continuous. There is also a positive response over four years showing that pricing decisions may vary according to the time needed by firms to adjust their financial needs. A similar pattern is exercised by the regulations proxy as the negative trend lasts for three periods. Export-orientation tends to increase the markup ratio only over two periods and subsequently, it tends to reduce the value of the price-cost margin. This outcome contradicts the long-run relationship and thus, it captures a negative effect on sectorial pricing decisions.

Productivity and the size of the manufacturing industry appear to have a stabilising effect on the markup ratio after the sixth period. This implies that productivity tends to increase the price-cost margin by less than 0.01% per annum implying that a 1% increase in productivity innovation causes a very small increase in the markup ratio before stabilisation. Moreover, the response of financial under-development and export-orientation to a markup standard deviation shock tends to stabilise after the fourth year following a positive response. Finally, the response of productivity and the size of the industry is negative over the initial 4 periods but subsequently, it steadily increases by less than 0.01% per annum.

Effectively, it can be concluded that more financially under-developed sectors tend to decrease their markup ratio in the long-run to attract more customers, but in the short-run there are periods when they pursue over-pricing strategies in order to increase their revenue. Export-oriented sectors tend to charge a higher price-cost margin in the long-run but in the very short-run they tend to reduce the markup ratio in order to increase their market share. Productivity and the value of the manufacturing industry appear to have a stabilising and long-run positive effect on pricing decisions, while market regulations tend to reduce the value of the markup-ratio.

The findings of this study complement the literature of imperfect competition and particularly, the studies of Martins et al. (1996), Molnár and Bottini (2010), Christopoulou and Vermeulen (2012) and Afonso and Costa (2013). The underlying argument is that manufacturing industries across the EU and the OECD group tend to adopt an imperfect competitive conduct as they can exercise their market power on the final selling price. Badinger (2007) and Bellone et al. (2016) also support this rationale because market share is an important contributor to such pricing decisions.

To this end, factors enhancing imperfect competitive conduct across industries are crucial determinants of operational strategies. One of the most important factors corresponds to liquidity constraints faced by many industries because restrictions to funding may have a significant effect on their pricing strategies (Raddatz, 2006). Given that the long-run results suggest that industries facing tighter financial constraints tend to charge a lower price-cost margin, it is evident that funding is a crucial determinant of production decisions. Therefore, this study adds value to the literature of imperfect competition and liquidity constraints suggesting that the EU manufacturing industries tend to exercise their market power on the markup ratio; however, liquidity restrictions and regulations force them to adopt more competitive strategies by reducing the price-cost margin in order to expand their market share (Ollivaud and Turner, 2013; Braund and Raddatz, 2016).

Overall, this study provides significant evidence of imperfect competitive conduct across the manufacturing sectors of the constituent 19 EU countries. The price-cost margin set by those sectors is affected by the degree of access to available liquidity, the exposure to exporting activities and ultimately, the level of productivity when market regulation and aggregate manufacturing value added are controlled for. To this end, the insights of this paper significantly contribute to the literature of imperfect competition as the estimated results complement the findings of many studies suggesting that market factors significantly influence the pricing decisions of the manufacturing firms.

5. Concluding remarks

The main scope of this study was to investigate the competitive structure across 19 EU manufacturing industries disaggregated into 10 2-digit NACE Rev.2 level sectors over 1995-2014. The empirical results suggest the presence of imperfect competition across every manufacturing industry as the selling price of the final product exceeds the marginal cost of production. It is also found that markup ratios across the east and south EU countries appear to be higher compared to their north and central counterparts. This outcome captures the structural difference of those economies and the overall conditions developed over 1995-2014 (McKee et al., 2012; Karanikolos et al., 2013; Matsaganis and Leventi, 2014).

Subsequently, the pricing decisions of the constituent manufacturing industries were tested with respect to liquidity constraints, export orientation and the level of productivity when market regulation and the size of the whole industry is taken into account. The estimated results showed that financially underdeveloped industries tend to charge a lower price-cost margin in order to increase their market share and thus, their revenue. Export-oriented industries tend to charge a higher price-cost margin as they utilise any returns earned by international activities and finally, more productive sectors reflect productivity improvements in the markup ratio. Those results are consistent with many empirical studies across the literature (Hall, 1988; Busse, 2002; Görg and Warzynski, 2003; De Loecker and Warzynski, 2012), therefore verifying the presence of imperfect competitive conduct across the 19 EU manufacturing industries.

According to those results, it is evident that the role of regulatory authorities is quite significant in the EU manufacturing industries as leading firms can exercise their market power on the markup ratio, thus limiting competition and exploiting consumer surplus. To this end, the role of regulatory institutions must be more active in order to reform the markets by abolishing inefficient regulations erecting entry barriers and allowing new firms to operate in the industry. Moreover, financial institutions must provide additional funding to small and medium sized firms to encourage them to improve their technology and increase their production. If such policies are implemented, they will be able to compete with leading firms and supply their products to consumers under a competitive price level. For this reason, this study complements the findings of OECD (2014a, 2014b, 2018) and joins the call for more market-friendly policy frameworks that will force uncompetitive and inefficient firms to exit the market. Subsequently, new productive firms being able to operate efficiently will enter the market and build their share in order to satisfy consumer preferences and contribute to industrial growth through constant improvement and expansion in both domestic and international markets.

Overall, the present study complements the argument that EU manufacturing industries tend to charge a markup ratio reflecting different forms of imperfect competitive conduct, while such decisions are influenced by liquidity constraints, exporting activities and the level of productivity.

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Appendix

Price-cost margin estimation

The methodological process employed for the estimation of the price-cost margin corresponds to the one presented by De Loecker and Warzynski (2012) and De Loecker and Eeckhout (2017). In particular, the markup ratio is obtained by leveraging cost minimisation of an input factor in the production process. Consider that *N* heterogeneous firms operate within an economy having access to a common production technology. The production function of each firm *i*, where *i*=1,2,…,*N* is captured by

$$Q(A_{it}, V_{it}, K_{it}) = A_{it}Q(V_{it}, K_{it}) \tag{A1}$$

where $Q(.)$is the production function, A_{it} is the Hicks-neutral productivity factor which is heterogeneous across firms, $V = (V_1, \dots, V_j)$ refers to the set of variable inputs utilised in the production process[22] and K is the capital stock. The Lagrangian objective function for the variable inputs is given by

$$L(V_{it}, K_{it}, \lambda_{it}) = {P_{it}}^V V_{it} + r_{it}K_{it} - \lambda_{it}[Q(A_{it}, V_{it}, K_{it}) - Q_{it}] \tag{A2a}$$

where ${P_{it}}^V$ is the price of variable input V, r_{it} is the user cost of capital[23], λ is the Lagrangian multiplier and Q_{it} is a scalar. The first order condition with respect to the variable input V is provided by

$$\frac{\partial L_{it}}{\partial V_{it}} = {P_{it}}^V - \lambda_{it}\left(\frac{\partial Q(A_{it}, V_{it}, K_{it})}{\partial V_{it}}\right) \tag{$A2b$}$$

[22] De Loecker and Warzynski (2012) treat V as a bundle of variable inputs and not as individual inputs, thus it is a scalar vector.

[23] As in the study of De Loecker and Eeckhout (2017), this paper also assumes that input markets are perfectly competitive and thus, $P^V$and r are equal to marginal revenue. In any form of imperfect competition, either the marginal cost of inputs would be higher compared to perfect competition or input prices would be lower as a result of market power (De Loecker et al., 2016).

If this expression is multiplied by $V_{it}/Q_{it}$and rearranged, the output elasticity of variable input V is obtained

$$\beta_{it}{}^{V} = \frac{\partial Q(A_{it}, V_{it}, K_{it})}{\partial V_{it}} \frac{V_{it}}{Q_{it}} = \frac{1}{\lambda_{it}} \frac{P_{it}{}^{V} V_{it}}{Q_{it}} \tag{A3}$$

According to this formulation, the Lagrange multiplier λ reflects the marginal cost of production according to the value of inputs. If we also assume that P corresponds to the price of the final product, then the ratio P/λ can be interpreted as the price markup over the marginal cost of production. Whenever this ratio is equal to unity, pricing decisions reflect perfect competitive conduct; any value higher than unity captures a form of imperfect competition in the market. Thereby, if we substitute this ratio in equation (A3), one obtains

$$\mu_{it} = \beta_{it}{}^{V} \frac{P_{it} Q_{it}}{P_{it}{}^{V} V_{it}} \tag{A4}$$

This expression includes two important elements: the ratio of revenue to the value of input V and the elasticity of output with respect to the variable input. Consequently, it is not necessary to observe the demand function of the market or market conduct. However, the main conditions that must be met in order to imply equation (A4) refer to the assumption of a production function according to (1) and the perfect competitive conduct in the input markets[24].

The estimation of equation (A4) necessitates the observation of total sales $P_{it}Q_{it}$ and the total variable cost of production $\sum_j P_{it}{}^{Vj} V_{it}{}^{j}$. For this reason, an industry-specific Cobb-Douglas production function is taken into account by adding logarithms to equation (A1)

$$q_{it} = a_{it} + \beta_v v_{it} + \beta_k k_{it} + u_{it} \tag{A5a}$$

[24] Moreover, there is no need to impose constant returns to scale, as it is assumed by Hall (1988) and Roeger (1995). Given that the Hall-Roeger formulation is estimated in first differences, it restricts the underlying demand system and thus, it results in consistently underestimated markup values (De Loecker and Warzynski, 2012).

At this stage, the suggestions of De Loecker and Eeckhout (2017) are implemented in this expression to control for simultaneity and selection bias, through which an unbiased output elasticity value with respect to variable inputs will be obtained. Under this approach, an optimal input demand equation is needed which is included in the Lagrangian expression (A2a). Finally, if it is also assumed that the unobserved productivity term depends on the input factors utilised in the production process (Olley and Pakes, 1992), equation (A5a) is transformed into

$$q_{it} = a_{it} + \beta_v v_{it} + \beta_k k_{it} + w_{it} + u_{it} = \psi_t(v_{it}, k_{it}) + u_{it} \tag{A5b}$$

where $w_{it} = w(v_{it}, k_{it})$ is the unobserved productivity term. If that term is assumed to follow an AR(1) process, the industry specific output elasticity is obtained by the moment condition

$$E[w_{it}(\beta_v)v_{it-1}] = 0 \tag{A6}$$

where the estimate ψ is used to obtain the value of output elasticity with respect to variable inputs. Under this approach, it is assumed that variable inputs at time *t* respond to productivity shocks, and also, a degree of correlation emerges between the current and lagged values suggesting the persistence of those shocks. Consequently, the firm-level price-cost margin is estimated by

$$\mu_{it} = \beta_v \frac{P_{it}Q_{it}}{\sum_j {P_{it}}^{V_j} {V_{it}}^j} \qquad (A7)$$

Table 1: Summary statistics for the constituent 19 EU manufacturing industries.

Countries/ Variables	Price-cost margin	Credit to GDP	Exports ratio	Productivity per worker	Regulation index	Total value to GDP
Austria	1.53	88.27	82.21	135.97	1.49	0.16
Belgium	1.51	58.20	72.50	144.27	1.16	0.12
Czech Republic	2.05	49.82	88.91	145.14	1.01	0.24
Denmark	1.75	173.66	61.14	148.19	1.69	0.11
Finland	1.76	93.55	68.16	126.66	1.88	0.14
France	1.54	94.18	77.72	125.25	1.08	0.10
Germany	1.53	79.40	83.61	121.75	1.70	0.20
Greece	2.09	116.65	32.84	133.59	0.33	0.08
Hungary	2.06	43.19	83.84	172.86	0.75	0.19
Ireland	2.38	81.38	84.29	126.41	1.76	0.17
Italy	1.70	88.91	83.08	118.68	0.64	0.13
Luxemburg	1.34	89.65	78.38	122.51	1.63	0.05
Netherlands	1.52	118.37	61.93	141.05	1.77	0.10
Portugal	1.80	129.73	75.03	140.41	0.75	0.11
Slovak Republic	2.23	49.90	87.91	175.03	0..83	0.19
Slovenia	1.65	54.94	83.03	152.28	0.66	0.19
Spain	1.74	130.00	69.37	157.85	0.75	0.12
Sweden	1.99	131.20	72.75	124.76	1.81	0.14
UK	1.46	138.48	73.82	148.60	1.83	0.08

Source: OECD and The Worldwide Governance Indicators databases.

Table 2: Sectorial markup ratios of the 19 EU manufacturing industries over 1995-2014.

Sector/Country	Austria	Belgium	Czech Rep.	Denmark	Finland	France	Germany
D: Manufacturing industry	1.54	1.53	1.95	1.56	1.96	1.57	1.46
D10T12: Food products, beverages and tobacco	1.58	1.46	1.95	1.29	1.44	1.74	1.19
D13T15: Textiles, wearing apparel, leather and related products	1.37	1.25	1.35	1.22	1.29	1.19	1.14
D16T18: Wood and paper products, and printing	1.61	1.32	1.83	1.16	1.67	1.20	1.27
D19: Coke and refined petroleum products	2.04	1.88	3.20	1.45	2.91	1.98	2.80
D20T21: Chemical and pharmaceutical products	1.87	1.85	2.39	2.32	2.27	1.90	1.78
D22T23: Rubber and plastics products, and other non-metallic mineral products	1.44	1.30	1.82	1.30	1.44	1.29	1.30
D24T25: Basic metals and fabricated metal products, except machinery and equipment	1.51	1.16	1.60	1.12	1.42	1.20	1.19
D26T28: Machinery and equipment	1.51	1.33	1.66	1.33	2.02	1.38	1.30
D29T30: Transport equipment	1.83	1.10	1.96	1.08	1.15	1.38	1.36
D31T33: Furniture; other manufacturing; repair and installation of machinery and equipment	1.31	1.17	1.55	1.40	1.23	1.12	1.07

Source: Estimations of equation (1).

Sector/Country	Greece	Hungary	Ireland	Italy	Luxemburg	Netherlands	Portugal
D: Manufacturing industry	1.87	1.87	2.01	1.79	1.38	1.62	1.69
D10T12: Food products, beverages and tobacco	1.97	1.41	2.61	1.78	1.27	1.86	1.68
D13T15: Textiles, wearing apparel, leather and related products	1.29	1.13	1.20	1.54	1.94	1.37	1.27
D16T18: Wood and paper products, and printing	1.92	1.36	2.38	1.67	1.29	1.34	1.71
D19: Coke and refined petroleum products	2.88	2.82	2.52	2.12	1.05	1.50	2.25
D20T21: Chemical and pharmaceutical products	1.85	2.27	3.17	1.68	2.06	2.25	1.68
D22T23: Rubber and plastics products, and other non-metallic mineral products	1.66	1.61	1.51	1.47	1.30	1.41	1.63
D24T25: Basic metals and fabricated metal products, except machinery and equipment	2.02	1.32	1.37	1.49	1.04	1.34	1.24
D26T28: Machinery and equipment	1.96	1.82	2.34	1.44	1.20	1.67	1.49
D29T30: Transport equipment	1.59	2.21	1.14	1.38	1.56	1.66	1.29
D31T33: Furniture; other manufacturing; repair and installation of machinery and equipment	1.72	1.30	2.06	1.62	1.12	1.10	1.27

Source: Estimations of equation (1).

Sector/Country	Slovak Rep.	Slovenia	Spain	Sweden	UK
D: Manufacturing industry	2.00	1.56	1.57	1.95	1.41
D10T12: Food products, beverages and tobacco	1.88	1.34	1.64	1.60	1.29
D13T15: Textiles, wearing apparel, leather and related products	1.25	1.03	1.26	1.37	1.18
D16T18: Wood and paper products, and printing	2.24	1.29	1.37	1.68	1.23
D19: Coke and refined petroleum products	2.46	1.01	3.63	2.52	1.20
D20T21: Chemical and pharmaceutical products	2.40	1.98	1.73	2.37	1.75
D22T23: Rubber and plastics products, and other non-metallic mineral products	1.89	1.39	1.36	1.42	1.16
D24T25: Basic metals and fabricated metal products, except machinery and equipment	2.17	1.32	1.29	1.54	1.09
D26T28: Machinery and equipment	1.49	1.30	1.34	1.95	1.12
D29T30: Transport equipment	1.99	1.44	1.40	1.71	1.13
D31T33: Furniture; other manufacturing; repair and installation of machinery and equipment	1.72	1.25	1.29	1.47	1.31

Source: Estimations of equation (1).

Table 3: Pesaran's cross-section dependence tests.

Variables	Scaled LM test			CD test		
	1	2	3	1	2	3
μ	22.20** [0.00]	21.93** [0.00]	19.61** [0.00]	16.94** [0.00]	16.87** [0.00]	15.85** [0.00]
fr	18.93** [0.00]	12.64** [0.00]	13.29** [0.00]	9.58** [0.00]	8.21** [0.00]	9.03** [0.00]
xp	109.68** [0.00]	106.38** [0.00]	100.85** [0.00]	45.88** [0.00]	45.35** [0.00]	44.21** [0.00]
pr	88.95** [0.00]	88.85** [0.00]	85.61** [0.00]	39.48** [0.00]	39.42** [0.00]	38.79** [0.00]
rg	10.75** [0.00]	9.95** [0.00]	8.73** [0.00]	4.84** [0.00]	4.69** [0.00]	4.78** [0.00]
vl	40.47** [0.00]	40.42** [0.00]	38.64** [0.00]	24.67** [0.00]	24.81** [0.00]	21.12** [0.00]

Notes: The null hypothesis denotes the absence of cross-sectional dependence in the series. The results are based on Pesaran's (2004) LM and CD tests. The values in brackets are p-values.
* Rejection of the null hypothesis at the 5% level of significance.
** Rejection of the null hypothesis at the 1% level of significance.

Table 4: Pesaran's panel unit root tests.

Variables		
	CIPS	CIPS*
μ	-1.741 [0.10]	-1.780 [0.09]
$\Delta\mu$	-9.552** [0.00]	-9.316** [0.00]
fr	-3.783** [0.00]	-3.889** [0.00]
Δfr	-11.62** [0.00]	-11.56** [0.00]
xp	0.333 [0.73]	1.015 [0.31]
Δxp	-5.732** [0.00]	-4.647** [0.00]
pr	0.783 [0.43]	1.499 [0.15]
Δpr	-7.097** [0.00]	-6.976** [0.00]
rg	-0.896 [0.37]	-0.979 [0.35]
Δrg	-9.467** [0.00]	-9.339** [0.00]
vl	1.867 [0.09]	1.688 [0.10]
Δvl	-8.061** [0.00]	-8.141** [0.00]

Notes: The values reflect *t*-statistic values. Δ denotes first differences. Pesaran's (2007) test is conducted including an intercept only. CIPS* corresponds to the truncated CIPS test. Rejection of the null hypothesis suggests stationarity in at least one manufacturing industry of the panel. The results are reported at lag k=3. The critical values for the test are -2.40 at 1% and -2.21 at 5% level of significance.
** Rejection of the null hypothesis at the 1% level of significance.

Table 5: Panel cointegration tests.

$\mu = f(fr, xp, pr, rg, vl)$	
DH_g	16.63** [0.00]
DH_p	20.47** [0.00]
$Panel\ v - Statistic$	-0.17 [0.42]
$Panel\ rho - Statistic$	-0.53 [0.31]
$Panel\ PP - Statistic$	-3.46** [0.00]
$Panel\ ADF - Statistic$	-2.75** [0.00]
$Group\ rho - Statistic$	-0.81 [0.23]
$Group\ PP - Statistic$	-7.54** [0.00]
$Group\ ADF - Statistic$	-5.75** [0.00]

Notes: DH_g refers to the group mean Durbin-Hausman statistic and DH_p is the panel statistic as developed by Westerlund (2008). The bandwidth selection M_i corresponds to the largest integer less than $4(\frac{T}{100})^{2/9}$ as proposed by Newey and West (1994). The remaining statistics refer to Pedroni's (2004) statistics which are one-sided tests with a critical value of -1.64.
The values in brackets are p-values.
* Rejection of the null hypothesis at the 5% level of significance
** Rejection of the null hypothesis at the 1% level of significance.

Table 6: Structural stability tests.

$\mu = f(fr, xp, pr, rg, vl)$	
Maximum LR F-statistic	4.82 [0.10]
Maximum Wald F-statistic	9.64 [0.10]
Exp LR F-statistic	1.03 [0.16]
Exp Wald F-statistic	2.66 [0.08]
Average LR F-statistic	1.56 [0.15]
Average Wald F-statistic	3.13 [0.15]
F-statistic	4.05 [0.72]
Scaled F-statistic	8.11 [0.24]

Notes: The structural stability tests are obtained according to the Quandt-Andrews unknown breakpoint test (Andrews, 1993; Andrews and Ploberger, 1994) and the multiple breakpoint test proposed by Bai and Perron (2003). The p-values are calculated using Hansen's (1997) method.
* Rejection of the null hypothesis at the 5% level of significance
** Rejection of the null hypothesis at the 1% level of significance.

Table 7: Long-run estimates.

Variables	CCE	FMOLS	GMM	ARDL
μ	1.00	1.00	1.00	1.00
fr	-0.022** (2.69)	- 0.001 (0.92)	-0.061* (2.10)	-0.064* (2.21)
xp	0.216** (5.78)	0.143** (5.69)	0.130** (6.17)	0.041 (1.86)
pr	0.352** (7.28)	0.393** (10.21)	0.359** (10.69)	0.418** (4.92)
rg	-0.043* (-2.02)	-0.006 (-0.24)	-0.023 (-0.86)	-0.683** (-4.85)
vl	0.966** (18.71)	0.406** (10.44)	0.412** (11.36)	0.582** (5.98)
$Time\ dummies$	[0.00]	[0.00]	[0.00]	[0.00]
$Wald\ test$	79.74** [0.00]	43.11** [0.00]	105.20** [0.00]	88.23** [0.00]
R^2	0.97	0.89	0.89	0.85

Notes: The results of the CCE are obtained by employing the common correlated effects technique proposed by Pesaran (2006). The standard errors of FMOLS are robust to the presence of heteroskedasticity and serial correlation. The instruments list in the GMM system consists of the lagged values of the endogenous explanatory variables. The numbers in parentheses are *t*-statistics. The numbers in brackets are *p*-values.
* Rejection of the null hypothesis at the 5% level of significance.
** Rejection of the null hypothesis at the 1% level of significance.

Table 8: Heterogeneous panel non-causality results.

Dependent variables	Sources of short-run causation (independent variables)					
	$\Delta\mu$	Δfr	Δxp	Δpr	Δrg	Δvl
$\Delta\mu$	-	2.22* [0.02]	3.92** [0.00]	2.32* [0.02]	2.00* [0.04]	1.74 [0.08]
Δfr	0.68 [0.49]	-	0.19 [0.84]	1.02 [0.30]	3.12** [0.00]	0.83 [0.40]
Δxp	1.17 [0.23]	7.47** [0.00]	-	0.36 [0.71]	2.62** [0.00]	1.94 [0.05]
Δpr	0.81 [0.41]	0.53 [0.59]	-1.81 [0.06]	-	-0.05 [0.95]	3.30** [0.00]
Δrg	2.09* [0.03]	3.50** [0.00]	1.16 [0.24]	1.53 [0.12]	-	2.23* [0.02]
Δvl	3.11** [0.00]	2.03* [0.04]	3.34** [0.00]	3.63** [0.00]	-0.04 [0.79]	-

Notes: The values are the Zbar-statistics as reported by Dumitrescu and Hurlin (2012). The lag length is set at *k*=2 according to SIC. The numbers in brackets denote p-values.
* Rejection of the null hypothesis at the 5% level of significance.
** Rejection of the null hypothesis at the 1% level of significance.