Cyclical Behavior of Markups: Theory and Firm-level Evidence

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Abstract

Using confidential firm-level data from the National Bank of Belgium, I document the heterogeneous response of firms' markups to the 2008 financial crisis. Overall, markups increased in the aftermath of the crisis and the effect was larger for highly financially constrained firms. I show that standard heterogeneous-firm models, featuring monopolistic competition and variable markups, are unable to replicate these patterns. I then introduce endogenous demand shifters which respond to firm investment in market share (e.g. quality). I show that the interaction of an increase in the cost of procuring inputs combined with an endogenous quality downgrading can rationalize the observed changes in firm-level markups.

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1 Introduction

The 2008 financial crisis exerted a severe impact on the real economy. The massive aggregate credit disruption resulted in an increase in firms' borrowing costs, thus generating problems for firms in procuring inputs necessary for production. As a consequence, the cost of producing one more unit of output sharply increased.[1] This increase in cost had a bigger impact the more financially constrained the firm was when the crisis hit. How did firms respond on average by setting the ratio of prices over marginal cost? Did these responses vary across firms?

These are relevant questions for both scholars and policy makers. Learning how individual firms adjust their markups *over time* provides insight on inflation dynamics and, hence informs the conduct of monetary policy. Moreover, accounting for the heterogeneity of firms' markups *in the cross-section* is crucial for the design of appropriate policy interventions to correct distortions in the output market. However, providing answers is a challenging task. From an empirical perspective, the estimation of markups is a complex exercise because of the unobservability of the marginal costs and the limited availability of detailed firm-level price data. From a theoretical perspective, the standard approach in macroeconomics and international economics is to assume constant elasticity of substitution between differentiated goods sold by monopolistically competitive firms. In this setting, markups are constant.

This paper proposes answers to the above questions through an empirical and a theoretical analysis, overcoming the limitations of previous studies on the topic. Using confidential firm-level data from the National Bank of Belgium over the period 1999-2014, I estimate firm-level markups. I document that, after the financial crisis, (i) firms increased their markups on average, and (ii) the markup increase is bigger for financially constrained firms. To rationalize these empirical findings, I build a model, featuring monopolistic competition, variable markups, heterogeneous firms, and endogenous quality choice. The paper is structured in two parts.

In the first part, following De Loecker and Warzynski (2012)'s approach, built on Hall (1986), I estimate Belgian manufacturing firm-level markup. The markup is defined as a wedge between revenue share and cost share of production. The advantage of this so-called production approach relies on the fact that, contrarily

[1]The 2008 financial crisis provides the best thought experiment to be considered in this framework. As highlighted by Christiano et al. (2015), the increase in firms' financing costs lead to an increase in their marginal costs, hence acting as cost-push shock.

to a demand approach, it is free from assumptions on consumers' demand. The richness of the dataset used allows me to obtain firm-level markup estimates for a very large sample of firms with different characteristics. The objective of this work is to investigate how firms set the markups in response to an increase in the common component of their cost, due to the 2008 aggregate credit disruption. Therefore, I first analyze the markup distribution over time, with a special focus on the crisis period. The results show an increase in the markup in 2009, which is consistent at different percentiles of the distribution. Moreover, the estimated markups show a countercyclical behaviour over the entire time span considered, thus contributing to the literature on markups' cyclicality. Then, I disentangle *highly finanancially constrained* firms from *lightly financially constrained* firms, by using an index introduced by Mulier et al. (2016). This measure contains information on firms' size, age, cash flow and leverage. It allows for distinguishing between firms that have been hit more or less severely by the financial crisis, capturing the idiosyncratic component of firms' cost. The empirical evidence about firms' heterogeneity shows two facts. First, *highly financially constrained* firms have a lower markup than *lightly financially constrained* ones over the entire period considered. Second, in the aftermath of the crisis *highly financially constrained* firms experienced a larger markup increase.

In the second part, I build a model able to rationalize and explain the behaviour of firms' markups during the crisis. Borrowing from the industrial organization and trade literature on the pass-through of costs into prices, the model overcomes the limitations of the workhorse model of monopolistic competition, i.e. Dixit and Stiglitz (1977). The latter is built on the restrictive assumption of a constant elasticity of substitution, which implies a non-varying demand elasticity and hence, a constant markup. Therefore, the idea is to build a model of monopolistic competition[2] that goes beyond this setting, featuring variable elasticity of substitution, and thus a markup that varies over time and across firms. Both the empirical (e.g. De Loecker and Goldberg (2014)) and theoretical literature (e.g. Krugman (1979), Mrázová and Neary (2014)) have shown that the most plausible assumption is the so called Marshall's second law of demand (hereafter MSLD) or subconvexity. This states that the elasticity of demand increases with prices and therefore, it implies an incomplete pass-through of costs into prices. Violating this assumption, hence assuming that the elasticity of demand decreases with prices, entails that firms with lower cost, in this framework *lightly financially constrained* firms, will set a lower

[2] I use a monopolistic competition model because, differently from competitive oligopoly, it allows for incorporating endogenous variable markups in a tractable way, in the presence of heterogeneous costs, as pointed out by Thisse and Ushchev (2016) in their review of the literature.

markup than higher cost firms. This prediction contradicts my empirical findings. Hence, I conclude that the MSLD is a reasonable assumption, that allows to generate endogenous markup in a model of monopolistic competition. Inspired by Zhelobodko et al. (2012), I build a model of endogenous markup, including two types of firms, heterogeneous with respect to their costs, that maximize profit subject to consumers' demand. Moreover, I analyze the predictions of the model, by assessing the impact of an increase in the common component of firms' cost. Then, I show that this model is not able to rationalize the observed changes in the markup. Following an increase in the cost, due to the aggregate credit disruption, this model will only predict a markup decrease. Excluding an implausible violation of the MSLD, it is necessary to introduce an endogenous demand shifter, which responds to firms' investment in market share (e.g. quality, advertising), along the lines of Antoniades (2015). Therefore, we enrich the previous model framework, by introducing quality that increases consumers' demand and enters as a cost in firms' problem. In this context, this cost component incorporates all the expenditures faced by the firms to enhance the relationship with their costumers or attract new ones, such as innovation, product quality, advertising. This course of actions cannot be pursued in case of particularly negative economic conjunctures, when the firms are forced to limit their investment in the acquisition of market shares, especially if they do not experience good financial health. In the aftermath of the financial crisis, the credit market disruption exerted un upward pressure on firms' marginal cost, as in Christiano et al. (2015). To offset the increasing cost, they decrease their investment in market share (e.g. downgrading quality or decreasing advertising expenditures), which leads to an upward adjustment of markups. Financially constrained firms experience more difficulties in procuring inputs than unconstrained ones. The presence of financial frictions amplifies the mechanism, leading to a bigger quality downgrading,[3] hence a bigger increase in firms' markup during the downturn. In conclusion, my model is able to reconcile the empirical evidence of an increase in firms' markup after the financial crisis, with the incomplete pass-through of a cost shock to prices.

The rest of the paper is organized as follows. Section 2 shows the empirical results. Section 3 presents the theoretical model. Section 4 relates this work to the literature. Section 5 concludes.

[3]This is in line with a survey conducted in US, Europe and Asia, by Campello et al. (2010), and showing that more financially constrained firms planned to cut their expenses in marketing by more than less financially constrained counterparts for 2009.

2 Empirics

In this section, I aim to investigate how firms set the markups in response to an increase in the common component of their cost, due to the 2008 aggregate credit disruption. Moreover, my objective consists in analyzing the heterogeneity of firms' responses. Specifically, I distinguish between firms that have been hit more or less severely by the financial crisis, capturing the idiosyncratic component of firms' cost. Building an index of financial constraints, I disentangle *highly finanancially constrained* firms from *lightly financially constrained* ones.

Data

I construct a firm-level dataset including a panel of Belgian firms for the sample period 1997-2014, operating in the manufacturing sector at the two-digit NACE-BEL Rev.2 industry level. The data are retrieved from two sources: (i) the annual account, which is filed by Belgian firms and collected by the Central Balance Sheet Office (CBSO) of the National Bank of Belgium; (ii) the VAT declaration, which is filed on line through INTERVAT by all enterprises that have a VAT number.[4] Merging data from both sources is essential for my analysis. In Belgium, small firms are not legally required to report as detailed information as required for larger firms, in their annual accounts. This causes an issue of sample under-representativeness, which is especially critical for the goal of my analysis. Therefore, in order to build a comprehensive dataset, I also use information from the firms' tax declarations, namely the nominal sales, as a measure of gross output (Y) and material expenditures, as a measure of intermediate input (M). Labour (L), as the average number of employees in full time equivalents, capital (K), as the total tangible fixed assets, are retrieved from the annual accounts. All nominal variables are deflated using the sector deflators provided by the National Bank of Belgium Online Statistics.

After cleaning[5] the raw data, I end up with an unbalanced panel of firms covering

[4] Data were kindly provided by the National Bank of Belgium during the author's traineeship.

[5] Before carrying out the mark-up estimation, I perform a three-step cleaning procedure for the firm-level raw data. First, I include in the analysis only firms with at least one employee, thus excluding the individual entrepreneurs. Second, I consider only firms with at least two consecutive years of observations, since, in order to perform our estimation, I need up to one-period lag of the variables of interest. Finally, I cleaned the raw data from values without an economic meaning to avoid that the results will be distorted by them. Particularly, I first dropped negative values of sales and then I excluded from the analysis observations with extreme values at the level of the estimated equation. Outliers are defined as values outside the interval given by the median of the

the period 1999[6]-2014, with 19'597 firms (159'259 observations in total). To build the index of firm level financial constraints, I use additional variables, retrieved from the annual accounts. In particular, I employ the total amount of firms' short-term debts, long-term debts and cash flow. The latter, defined by the Earnings Before Interest and Tax (EBIT) plus depreciation, is directly provided as a raw variable ratio.

Table 1, in the Appendix, shows the summary statistics of the data used to estimate markups.

Financial Constraint Index

One of the aims of this work is to document and theoretically investigate the way markups have been set during the financial crisis by heterogeneous firms. Accounting for heterogeneity in firms' specific characteristics allows me to distinguish between firms that have been hit more or less severely by the financial crisis shock.

For this purpose I use an index, introduced by Mulier et al. (2016), which includes information not only about age and size of the firms, but also about firms' cash flows, as a proxy of the debt capacity of the firm, and the leverage ratio, proxying for solvency risk. A firm can be qualified as financially constrained if it is unable to obtain the necessary amounts of external finance to carry out its investment and growth. Since financial constraints are not empirically observable, scholars have strived to develop methods to identify financial constraints using firms' characteristics, as extensively reviewed by Silva and Carreira (2012). In my work I choose the age-size-cashflow-leverage (ASCL) index because it has three main features that are particularly suitable for my analysis. First, it has been built and validated against alternative indices widely used in literature, for unquoted European SMEs over different countries (including Belgium). Second, it is a simple and parsimonious index, including all necessary information to disentangle constrained from unconstrained firms, without the need to use variables non-existent for unquoted SMEs. Finally, this index is able to detect constrained firms as the ones paying higher interests on their debt and displaying a high sensitivity of cash flow to investment. Therefore, to provide an extreme example, the idea is that a small, young firm with low cash flow and high leverage ratio is likely to experience serious troubles during the financial

distribution of each variable by sector-year plus/minus five times the interquartile range of the same distribution. I apply this routine to all the variables of interest by two-digit sector and year.

[6] I lose the first two years of observations for the markup estimation.

crisis, because it faces a higher cost of external financing, with respect to a large, old firm with high cash flow and low leverage. In the presence of frictions in accessing external finance, more financially constrained firms will face higher costs of financing. This will imply that they will need to pay a higher interest rate, thus resulting in a very high cost of working capital (as highlighted by Christiano et al. (2015)) and therefore they will face higher cost in procuring inputs necessary for productions.

The index is built following a scoring system. If a firm is younger than its industry median in a given year, it gets a score of 1 for age and 0 otherwise. The same procedure applies for size, and average of the cash flow to capital ratio over the two previous years. For leverage, if a firm has a leverage ratio higher than its industry median in a given year, it gets a score of 1 and 0 otherwise. Finally, the scores are summed, obtaining for each firm-year observation an index going from 0 (unconstrained) to 4 (constrained). Firms are considered as *highly financially constrained* if the ASCL-index is greater or equal than 2, and *lightly financially constrained* if less than 2. Moreover, I perform an adjustment with respect to the original procedure proposed by Mulier et al. (2016). Before building the final categorical variable, I demean by sector means every variable used in order to account for sector effects that could otherwise bias the resulting classifications.

Markup Estimation

To estimate firm-level markups, I follow De Loecker and Warzynski (2012)'s approach, which builds on the framework introduced by Hall (1986). Each period t the i-th firm within an industry produces output using the following production function:

$$Q_{it} = Q_{it}(L_{it}, M_{it}, K_{it}, \omega_{it}) = F(L_{it}, M_{it}, K_{it}; \beta)exp(\omega_{it}) \quad (1)$$

where Q_{it} is the gross output, the inputs of production are capital, K_{it}, labour, L_{it}, and materials, M_{it},[7] β represents a set of common technology parameters and ω_{it} is a firm-specific productivity factor. Hence, the model does not impose any constraint on the form of the technical progress, the only assumption is that the function $F(\cdot)$

[7] I use the gross output approach, thus in contrast to the value-added measure of output, I also include materials among the inputs of production. At the aggregate level the two measures are close, while at the industry or sector level, the use of intermediate input is a much higher proportion of gross output. Therefore, in this case the gross output-based measure is a more suitable indicator.

is continuous and twice differentiable with respect to its argument.

Firms choose the amount of variable inputs in order to minimize cost given their production function (Eq. 1). Since our model is designed for Belgian economy, which features high labor market rigidity, [8] I assume not only capital as fixed and dynamic input of production, but labor as well. The choice of material as variable input of production used to infer firms' markups has been recently considered promising in the literature. Bils et al. (2018) show that the intermediate inputs provide a truer measure of cyclical distortion in the product market with respect to hourly wages for workers. Therefore, I consider labor and capital to be state variables, chosen at $t-1$, while the free intermediate input variable is chosen at t after the productivity shock is realized and its choice does not affect future profits. Firms solve the following constrained minimization problem:

$$\begin{aligned} &\underset{M_{it}}{\text{MIN}} \quad W_{it}L_{it} + P_{it}^{M}M_{it} + r_{it}K_{it} \\ &\text{s.t.} \qquad Q_{it} = Q_{it}(L_{it}, M_{it}, K_{it}, \omega_{it}) \end{aligned} \tag{2}$$

The first order condition implies:

$$\frac{\partial Q_{it}(\cdot)}{\partial M_{it}} = \frac{1}{\lambda_{it}} P_{it}^{M} \tag{3}$$

where P_{it}^{M} is the price of material and λ_{it} is the Lagrange multiplier.
Moreover, according to the theory of imperfect competition, I define the mark-up as the ratio of output price (P_{it}) over marginal cost (MC_{it}), which, in this specification, is λ_{it}. Hence, using the definition of markup and multiplying both sides by $\frac{M_{it}}{Q_{it}}$, I can rewrite the first order condition 3 as:

$$\underbrace{\frac{\partial Q_{it}(\cdot)}{\partial M_{it}} \frac{M_{it}}{Q_{it}}}_{\theta_{it}^{M}} = \mu_{it} \underbrace{\frac{P_{it}^{M}}{P_{it}} \frac{M_{it}}{Q_{it}}}_{\alpha_{it}^{M}} \tag{4}$$

where θ_{it}^{M} is the output elasticity for material input and α_{it}^{M} is the cost share of material relative to total sales, i.e. $P_{it}Q_{it}$. Therefore, the firm-level markup can be

[8] As highlighted in De Loecker et al. (2014) labour market in Belgium has been quite rigid in the past years. Labour market protections are quite restrictive in terms of work rules in comparison to the other OECD countries. The OECD (2013) lists Belgium among the countries with the most stringent restrictions in terms of employment protection. Thus, labour adjustments, such as firing and hiring costs, are high.

obtained as :

$$\mu_{it} = \theta_{it}^{M} (\alpha_{it}^{M})^{-1} \tag{5}$$

Although the cost share of any input relative to total sales (α) can be computed for every firm in each time period, the output elasticity with respect to material input (θ) is not observed. Thus, to obtain the output elasticity, I need to estimate the production function.

First, I consider the logarithm transformation of the production function 1, using the lower case letters for the logs of the variables:

$$y_{it} = f(l_{it}, m_{it}, k_{it}; \beta) + \omega_{it} + \epsilon_{it} \tag{6}$$

where ω_{it} is the unobserved productivity shock which is potentially correlated with the inputs and hence, impacts the firm's decision rule, while ϵ_{it} contains both unanticipated shocks and measurement errors which are not correlated with inputs; y_{it} is the observed logged output given by the sum between q_{it} and ϵ_{it}; and $f(\cdot)$ is approximated by a Cobb-Douglas production function. Results are robust to the use of alternative specification, e.g. translog function.

Equation 6 cannot be consistently estimated using OLS method because of the endogeneity of firms' choices of factor inputs in relation to their productivity ω_{it}, as first pointed out in the seminal paper by Marschak and Andrews (1944). Several methods have been proposed in the literature to perform the production function estimation to deal with this endogeneity issue. We follow the Control Function approach first used to estimate the production function by Olley and Pakes (1996), then improved by Levinsohn and Petrin (2003) and Ackerberg et al. (2015). The main idea is to use the intermediate input levels as a proxy for the productivity ω_{it}. Demand for the intermediate input m_t is assumed to depend on the firm's state variables k_{it}, l_{it}, ω_{it} and control variables $\mathbf{z_{it}}$ potentially affecting optimal input demand choice:[9]

$$m_{it} = m(l_{it}, k_{it}, \omega_{it}, \mathbf{z}_{it}) \tag{7}$$

[9]Following De Loecker and Warzynski (2012) I include in the vector of control variables , $\mathbf{z_{it}}$, the lagged input. It is possible to perform an extension, where I include the financial constraint index in the vector of control, since it could potentially affect firms' optimal input demand.

Levinsohn and Petrin (2003) show that the material demand function is monotonically increasing in ω_{it}. As a result, it can be inverted, so that I can recover the unobservable ω_{it} as a function of the inputs of production and the control variables.

$$\omega_{it} = h(l_{it}, k_{it}, m_{it}, \mathbf{z}_{it}) \tag{8}$$

Moreover, another identification restriction needed is that the productivity shock evolves according to a first-order Markov process:

$$\begin{aligned} &\omega_{it} = E[\omega_{it}|\Omega_{it}] + \xi_{it} = E[\omega_{it}|\omega_{it-1}] + \xi_{it} \\ \Rightarrow \quad &\omega_{it} = g(\omega_{it-1}) + \xi_{it} \end{aligned} \tag{9}$$

where Ω_{it} is firm's i information set at t.
We follow a gross-output production function estimation. The procedure, as developed by Ackerberg et al. (2015), consists of two steps.

In the first stage, I rewrite the production function from equation 6 as:

$$y_{it} = \phi_{it}(l_{it}, k_{it}, m_{it}, \mathbf{z}_{it}) + \epsilon_{it} \tag{10}$$

where $\phi_{it}(l_{it}, k_{it}, m_{it}, \mathbf{z}_{it}) = f(l_{it}, m_{it}, k_{it}; \beta) + h(l_{it}, k_{it}, m_{it}, \mathbf{z}_{it})$. Substituting a third-order polynomial approximation in the inputs of production in place of $\phi_{it}(l_{it}, k_{it}, m_{it}, \mathbf{z}_{it})$ and estimating it by OLS, I get an estimate for expected output, $\hat{\phi}_{it}$, and the residual, $\hat{\epsilon}_{it}$.

In the second stage, I estimate the productivity coefficient for any value of β as:

$$\omega_{it}(\beta) = \hat{\phi}_{it} - \beta_l l_{it} - \beta_m m_{it} - \beta_k k_{it}$$

Using the law of motion for productivity from equation 9, I regress $\omega_{it}(\beta)$ on its lag $\omega_{it-1}(\beta)$ and I get the residuals $\xi_{it}(\beta)$. At this point, I can estimate the production function parameter $(\hat{\beta})$ exploiting the moment conditions $E[\xi_{it}\mathbf{z}^{\mathbf{k}}_{\mathbf{it}}] = 0$, where k denotes the elements of the instrument vector:

$$\mathbf{z}_{\mathbf{it}} = [l_{it}, m_{it-1}, k_{it}] \tag{11}$$

The production function parameters solve the following minimization:

$$\underset{\beta}{argmin} = \left\{ \sum_k \left(\sum_i \sum_t \xi_{it} z_{it}^k \right)^2 \right\} \tag{12}$$

After having performed the two stage estimation, I have all the necessary elements to compute the markups with equation 5. First, I compute the output elasticity with respect to material (θ_{it}^M), which is given by $\hat{\beta}_m$. Second, I compute the material expenditure share ($\hat{\alpha}_{it}^M$) as the ratio between material and sales. Then, I correct the share multiplying it by $e^{\hat{\epsilon}_{it}}$, using $\hat{\epsilon}_{it}$ that I compute in the first stage. This allows me to remove any variation in the share due to variation in output caused by measurement error or unanticipated shocks to productivity.

Finally, I use equation 5, to get our markup estimates.

Table 2 in the Appendix, presents the summary statistics of the estimated markup. These are consistent with previous studied on Belgian manufacturing sector, e.g. De Loecker et al. (2014), in terms of sector ranking.

Empirical Evidence

After obtaining firm-level markup estimates and an index to disentangle *highly financially constrained* from *lightly financially constrained* firms, I document two facts by means of a graphical analysis.

Fact 1: The markup increases on average during the financial crisis

The aggregate markup distribution, weighted by market shares, shows a sharp increase during the 2008 financial crisis, as in Figure 1. This behaviour is consistent and largely reproducible at the different percentiles. The result is robust to considering alternative measures of markup. In the appendix, I show a similar plot realized using two different measures of price cost margins (see Figures 5 and 6). These are simple indices that do not require any estimations and are defined as the ratio of the difference between sales and variable cost to sales. Moreover, this empirical evidence is confirmed by looking at sector specific markups behaviours over time, as in Figure 4 in the Appendix.

Two complementary findings emerge by analysing the behaviour of the aggregate markup for Belgian manufacturing sector. The first one contributes shedding light on the behaviour of markup over the business cycle, by means of a firm-level analysis. As illustrated in detail in Figure 7 in the Appendix, I find a countercyclical markup for Belgian manufacturing firms over 1999-2014. Comparing the cyclical component of the markup to the one of the Belgian real Gross Domestic Product extracted using the Hodrick-Prescott filter, I find a contemporaneous correlation of -0.85, significant at 1% level. The second one concerns the trend of the aggregated firm-level markup. An important caveat concerns the short time length of our series, hence it is not possible to draw clear conclusions about the markup trend. However, differently from what observed by De Loecker and Eeckhout (2017) for the United States in 1960-2014, Belgian manufacturing markup does not show a clear increasing trend. This result is confirmed by De Loecker et al. (2018) in a recent study about the long-run markup behaviour across the entire universe of Belgian firms over a long sample period starting in 1980. This distinctive behavior of Belgian markups with respect to other economies is also in line with the findings of Autor et al. (2017). These authors, by investigating several OECD countries, find that Belgium is the only country to show a positive relationship between the change in the labor income share and the change in concentration across industries.

Figure 1: Markup weighted distribution over time. Note: The figure shows the mean, the median, the 75th and the 90th percentiles of the markup distribution over time, weighted by market share, for the sample 1999-2014. The shaded area represents the recession period.

Fact 2: The markup increases by more for *highly financially constrained* firms

By using the index previously described, I plot, in Figure 2,the weighted mean of the estimated markups for *highly financially constrained* and *lightly financially constrained firms*. The first takeaway from the figure concerns the lower level of markup for highly financially constrained firms, which are higher-cost firms, over the entire sample analyzed. The difference is statistically significant[10], as shown by the 95% confidence bars. This result is in line with the expectation that less constrained firms are able to set a higher level of markup with respect to more constrained counterparts. The second important observation concerns how the two types of firms set their markups during the financial crisis. The mean weighted markup shows an increase for both categories of firms, however, high financially constrained firms present a more sustained increase of the markup, in terms of magnitude. In the Appendix, I perform a robustness check by only considering the leverage ratio to disentangle between different types of firms, and the result is confirmed.

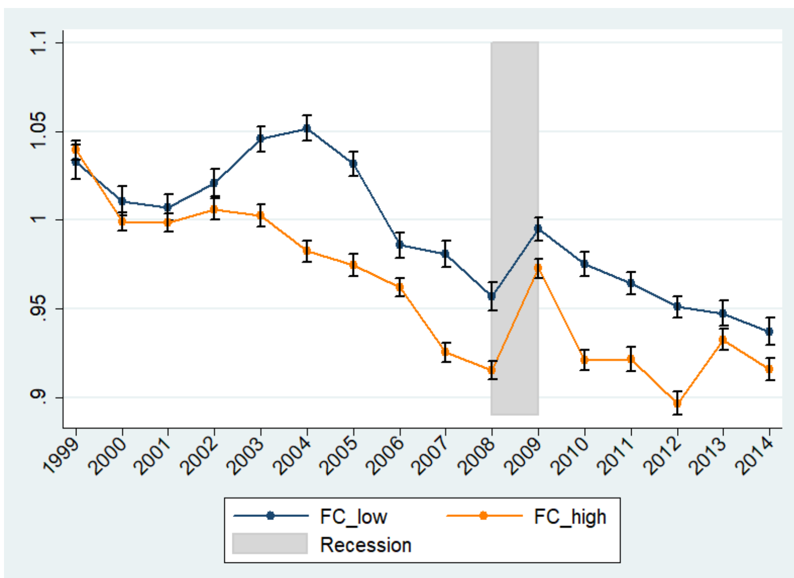

Figure 2: Markup for high and low leverage firms. Note: The figure shows the weighted mean of the markup for *lightly financially constrained* (blue line) and *highly financially constrained* (orange line) firms, for the sample 1999-2014. The vertical bars represent the 95% confidence intervals. The shaded area represents the recession period.

[10]The first two years of the sample are not significantly different, since the index is built by considering, for leverage and cash flow variables, the average of the previous two years.

3 Inspecting the mechanism

Before describing the model built to rationalize the empirical evidence, I provide an intuition of the necessary elements to include in order to replicate the facts previously described. I begin by stating three important elements.

First, the empirical evidence clearly shows that markups do vary over time and across firms. From a theoretical perspective, this finding offers a first important conclusion. The assumption of constant elasticity of substitution, made in the workhorse model of monopolistic competition (i.e. Dixit and Stiglitz (1977)) and predicting a constant elasticity of demand and hence a constant markup, is implausible. Therefore, I need to depart from it. However, if the price elasticity of demand is not constant, how does it vary? The literature of monopolistic competition with endogenous markup (e.g. Zhelobodko et al. (2012) and Mrázová and Neary (2014)), reformulates an assumption stated by Marshall (1890) and defined as "Marshall's second law of demand" (henceforth MSLD),[11] proposes that the elasticity of demand increases with prices along a demand curve. Krugman (1979) states that this is a necessary and sufficient condition to get "reasonable" competition effects under monopolistic competition. The direct implication of this assumption is the incomplete pass-through of cost to prices, for which there is abundant empirical evidence, as shown by De Loecker and Goldberg (2014).

Second, from the empirical evidence about firms' cross-sectional heterogeneity, the markup estimations display that more financially constrained firms (firms with higher costs) set a lower level of markup over the entire sample. This element shows that I can exclude any violation of the MSLD assumption from my model. If the MSLD does not hold, hence the elasticity of demand decreases with prices, lower cost firms (in our case less financially constrained firms) set a lower markup than higher cost firms.

Finally, the two main facts, shown in Section 2, state that after the financial crisis, notably after an increase in the common component of firms' cost, the markup increases and the higher are firms' constraints (higher costs) the bigger is the markup's increase. These facts imply some model predictions with regard to the markup. To replicate the empirical findings, the markup, (i) has to be an increasing function of the common component of firms' costs, (ii) it has to be higher in level for

[11] This denomination has been made to distinguish it from the first law of demand stating the inverse relationship between price and quantity demanded.

lightly financially constrained firms and (iii) its increase has to be bigger for *highly financially constrained* firms.

Considering these three elements, I conclude that, to rationalize the empirical evidence by means of the most parsimonious model of monopolistic competition,[12] I need to account for two main features: (i) heterogeneous firms with different costs; (ii) endogenous markup, generated by MSLD assumption, hence the markup of higher cost firms is lower than lower cost firms' markup. Moreover, the model needs to generate two predictions: (i) the markup is an increasing function of firms' costs; (ii) the markup is a convex function of firms' costs.

Therefore, I proceed in two steps. First, I build a model of monopolistic competition with endogenous markup, inspired by Zhelobodko et al. (2012), including two types of firms, heterogeneous with respect to their degree of financial constraint, which is an idiosyncratic component of their cost. Second, I show that this model is not able to rationalize the observed changes in the markup after an increase in the common component of firms' cost. Hence, I introduce an endogenous demand shifter, which responds to firms' investment in market share (e.g. quality, advertising), along the lines of Antoniades (2015).

3.1 Standard Model

Consumers

Consumers choose the quantity of output to maximize utility. They exhibit additively separable preferences over a continuum of imperfectly substitutable goods, each one produced by an individual firm, indexed by $i \in [0, M]$, where M is the mass of firms in the economy

$$\max_{q_i} \int_0^M u(q_i)di \qquad \text{s.t.} \int_0^M p_i q_i di = 1 \tag{13}$$

where $u(q_i)$ is twice continuously differentiable, strictly increasing, and strictly concave over $[0, \infty]$.

[12] I use a monopolistic competition model because, in contrast to competitive oligopoly, it allows me to incorporate endogenous variable markups in a tractable way in the presence of heterogeneous cost, as extensively reviewed by Thisse and Ushchev (2016).

Firms

There exist two types $j = H, L$ of firms in the economy, heterogeneous in terms of marginal costs:

$$\nu(c_j) = c\tau_j \tag{14}$$

where c captures the common component of the cost given by the variable cost of production and a cost of procuring inputs; τ_j is the idiosyncratic component, capturing the level of financial constraint: $j = L$ for lightly financially constrained firms, $j = H$ for highly financially constrained firms.

Every firm of type $j = H, L$ maximizes its profit, given the consumers' demand $p(q)$:

$$\Pi_j = p(q)q - \nu(c_j)q$$

Therefore, the markup can be written as a function of the marginal cost:

$$\mu_j = \frac{\varepsilon_d}{\varepsilon_d - 1} = \mu(\nu(c_j))$$

Model Predictions

A financial crisis shock is identified by an increase in the cost of procuring inputs, c. Hence, the impact on the markup for a generic firm (type $j = L, H$), is given by:

$$\frac{d\mu(\nu(c_j))}{dc} = \frac{\partial\mu(\nu(c_j)}{\partial\nu(c_j)}\frac{\partial\nu(c_j)}{\partial c_j} < 0$$

This implies that the markup decreases after an increase in the common component of the cost. This prediction contradicts the empirical evidence.

Proposition 1: *If MSLD holds, the markup decreases in response to an increase in the common component of the cost.*

Proof: If MSLD holds, it is easy to show how a higher cost corresponds to a lower markup. Given the monopolistic competition framework, $\frac{\partial p(\cdot)}{\partial\nu(\cdot)} > 0$, thus, this implies that $\frac{\partial\varepsilon_d(\cdot)}{\partial\nu(\cdot)} = \frac{\partial\varepsilon_d(\cdot)}{\partial p(\cdot)}\frac{\partial p(\cdot)}{\partial\nu(\cdot)} > 0$. Moreover, since $\frac{\partial\mu}{\partial\varepsilon_d} = -\frac{1}{(\varepsilon_d-1)^2}$, a variation of

$$\frac{\partial\mu(\cdot)}{\partial c} = -\frac{1}{(\varepsilon_d - 1)^2}\frac{\partial\varepsilon_d(\cdot)}{\partial p(\nu(c_j))}\frac{\partial p(\nu(c_j))}{\partial\nu(c_j)}\frac{\partial\nu(c_j)}{\partial c}$$

Which is obviously negative, thus predicting a decreasing markup function. Therefore, if MSLD holds, the thesis of increasing function is never satisfied.

This *impasse* can be solved pursuing two different approaches. The first one is to modify the original problem, introducing an endogenous demand shifter. In this way, it will be possible to satisfy the empirical evidence, without violating the MSLD. The second one consists in violating the MSLD. However, as also previously stated, a violation of this assumption will generate a direct contradiction of the empirical evidence, by predicting a higher markup for higher cost firms. Therefore, the only possibility is to follow the first approach, to rationalize the empirical findings, without violating the MSLD assumption.

Remark: *To obtain an increasing markup in response to an increase in c, without violating the $MSLD$, it is necessary to introduce a shifter in the demand curve*

This remark is intuitive. Since the MSLD holds along a demand curve, a shift in the curve results in the desired result, without violating this assumption.
Therefore, I introduce an endogenous demand shifter à la Antoniades (2015).

3.2 Introducing Quality Channel

I introduce in the standard heterogeneous firms model with endogenous markup, a quality channel, along the lines of Antoniades (2015). In this section, I highlight the main differences with respect to the previous model.

Consumers

They face the same maximization problem as previously described in equation 13. The difference lies in the utility function. The latter includes not only quantity q_i, but also a quality parameter z_i. This is a parameter increasing the consumer's demand, that can be interpreted as a generic investment in market share, which is defined as quality by Antoniades (2015). For example, a company may invest in advertising expenditures with the aim of increasing market shares.

For ease of exposition, I use a linear demand function, generated by a quadratic utility function. This is done without loss of generality. The same results could be obtained by using other types of preferences, as for example Kimball or translog preferences, which are both homothetic, as shown by Parenti et al. (2017). The only requirement to be satisfied is that they need to be in the class of the subconvex preferences, or in other words, they need to satisfy the MSLD assumption.

The utility function can be written as:

$$u(q_i) = (\alpha + \beta z_i)q_i - \frac{\gamma}{2}q_i^2 \tag{15}$$

where α represents the willingness to pay for the good. Moreover consumers express not only a taste for variety, through γ, but also a taste for quality, through β. The inverse demand for each good is thus:

$$p(q) = \frac{\alpha - \gamma q + \beta z}{\lambda} \tag{16}$$

where λ is the Lagrange multiplier of the consumer's maximization problem. It represents the marginal utility of income: $\lambda = \int_0^M u'(q_i)q_i di$. Given the aim of the model, I assume that firms consider λ as a parameter, i.e. they are λ-takers. Relaxing this assumption, the main results still hold.

Firms

Quality enters as a cost in the firms' problem. The total cost faced by firm j is:

$$TC = c_j q + \delta_j z q + \theta z^2$$

where c_j is the variable cost of production, $\delta_j z$ is the cost of quality upgrading and $\theta z(c)^2$ is a fixed cost of increasing quality. We assume quality z is endogenously chosen by firms, together with the quantity of goods q.

Firms' maximization problem, in this new framework, becomes:

$$\max_{q,z} \Pi = \Big(\frac{\alpha - \gamma q + \beta z}{\lambda}\Big)q - [(c_j + \delta_j z)q + \theta z^2]$$

The solution to firms' optimization problem gives the optimal quantity, q^* and the optimal quality z^*, which is a function of the production cost c:

$$q^* = \frac{\alpha + \beta z - \lambda(c_j + \delta_j z)}{2\gamma}$$
$$z^* = \frac{(\beta - \lambda\delta_j)(\alpha - c_j\lambda)}{4\theta\lambda\gamma - (\beta - \lambda\delta_j)^2} = z^*(c_j)$$

z is a decreasing function of c: $z'(c_j) < 0$. Firms face a different marginal cost, with respect to the previous model, which is augmented by quality: $\nu(c_j) = c_j + \delta_j z(c_j)$. In this framework, the markup can be expressed as:

$$\mu = \frac{\alpha + \beta z(c_j)}{2\lambda(\delta z(c_j) + c_j)} + \frac{1}{2}$$

Model predictions

In the aftermath of the financial crisis, an increase in the cost of procuring inputs, i.e. an increase in c, has the following impact on the markup:

$$\frac{d\mu}{dc} = \underbrace{-\frac{(\alpha + \beta z(c_j))}{2\lambda\nu(\cdot)^2}}_{\text{Direct impact}} + \underbrace{z'(c_j)\frac{(\beta c_j - \alpha\delta_j)}{2\lambda\nu(\cdot)^2}}_{\text{Indirect impact}}$$

The financial crisis shock generates two effects on the markup: (i) *the cost channel*, which is a direct impact of an increase of c on the markup, through the marginal cost, hence, having a negative impact on the markup; (ii) *the quality channel*, which is an indirect impact of an increase of c through the quality z. The latter, generating an endogenous decrease in quality, has a positive impact on the markup if $\alpha\delta_j > \beta c_j$. This implies that the cost of quality upgrading needs to be higher than the consumer's taste for quality.[13] If this is the case and the *the quality channel* is stronger than *the cost channel*, the markup increases after a positive shock on c. Therefore, the first prediction can be verified.

The second prediction to test concerns the convexity of the markup. In particular, supposing indirect impact is stronger than the direct impact, the heterogeneous response of the two types of firm is given by:

$$\frac{d\mu(c_L)}{dc} = -\frac{(\alpha + \beta z(c_L))}{2\lambda\nu(c_L, z(c_L))^2} + z'(c_L)\frac{(\beta c_L - \alpha\delta_H)}{2\lambda\nu(c_L, z(c_L))^2}$$

$$\frac{d\mu(c_H)}{dc} = -\frac{(\alpha + \beta z(c_H))}{2\lambda\nu(c_H, z(c_H))^2} + z'(c_H)\frac{(\beta c_H - \alpha\delta_L)}{2\lambda\nu(c_H, z(c_H))^2}$$

[13] If the taste for quality from the demand side is too high, the firm will be constrained to keep the same level of quality to be able to satisfy consumers' demand.

This implies that if $|z'(c_H)| > |z'(c_L)|$, i.e. the magnitude of the variation in quality for high cost firms is bigger than the one for low cost firms, I get exactly what I observed in the data, that is:

$$\frac{d\mu(c_H)}{dc} > \frac{d\mu(c_L)}{dc}$$

markup increases by more for highly financially constrained firms, in response to a shock in c.

Figure 3 shows a simulation of possible scenarios, with parameters fulfilling all the conditions I have defined so far. The difference between the two curves is a different τ and a different δ. In this context, assuming an equal starting point in terms of marginal cost, the main discrimination is given by its "composition": a highly constrained firm will have higher τ (difficult access to credit) but lower δ (smaller investment in quality), while a lightly constrained firm will have smaller τ (easy access to credit) but higher δ (higher investment in quality). It can also be shown that the derivative of z with respect to δ is positive, i.e. a bigger δ yields a less negative variation in z. When all the conditions on the parameters are met, it is easy to infer from the plot that, albeit the markup of financially constrained firms is lower than non-constrained firms, the markup will increase more steeply for the former because of a more acute reduction in z. Note, however that the mechanism of reduction in quality cannot be pursued indefinitely: when z reaches zero, the firm cannot use this indirect channel to further increase its markup. This limitation, besides being reasonable and dictated by common sense, is also necessary to prevent the markup of the more financially constrained firm to be higher than the less financially constrained firm, as this would contradict the empirical data and the first theoretical statement.

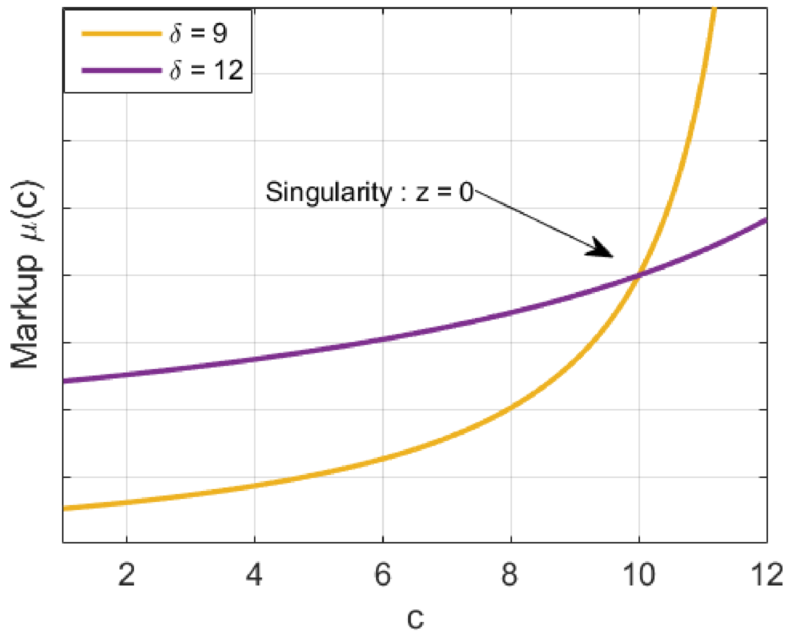

Figure 3: Model simulation. Note: The figure shows a simulation of the model predictions, in line with the empirical evidence. The yellow line is the markup for low cost, hence highly financially constrained firms with lower δ, while the purple line represents the markup for low cost firms, hence lightly constrained firms with higher δ.

In the aftermath of the 2008 financial crisis, firms faced an increase in the cost of procuring inputs, which raised their marginal cost (*cost channel*). To offset the increasing cost, they decreased their investment in market share, downgrading quality (*quality channel*), hence, adjusting their markups upward. If the *quality channel* is stronger than the *cost channel*, the model predicts an increase in the markup. This mechanism is corroborated by the empirical evidence, showing a contraction in the expenditure on advertising for Belgian manufacturing sector, during the financial crisis (see Figure 8 in the Appendix).

Moreover, *highly financially constrained firms* react to the increase in the marginal cost by a bigger quality downgrading with respect to *lightly financially constrained firms*. If the firm was characterized by high financial constraint, it experienced more difficulties in procuring inputs than the firms in better financial positions. The presence of financial frictions amplified the mechanism, leading to a bigger increase in firms' markups during the downturn. This prediction is in line with a survey conducted in US, Europe and Asia, by Campello et al. (2010), showing that more financially constrained firms planned to cut their expenses in marketing by more than less financially constrained counterparts for 2009.

3.3 Related Literature

This paper contributes to the empirical and theoretical literature on markups.

Empirical Studies
On the empirical side, the variation in markups has been investigated from three different perspectives.

In the context of business *cycle* fluctuations of markups, several industry-level studies have been conducted over time. However, the empirical evidence is still mixed. Some works find countercyclical markups (e.g. M. Bils (1987), Chevalier and Scharfstein (1996), Rotemberg and Woodford (1999), Gali et al. (2007), Gilchrist et al. (2017), Bils et al. (2018)), while others find procyclical or acyclical price to cost margin ratios (e.g. Nekarda and Ramey (2013), Kim (2015), Stroebel and Vavra (2015)). My contribution to this literature consists in providing new evidence on the cyclical Belgian manufacturing sector, by finding countercyclical markup. Contrary to the previous studies, I use a detailed firm-level dataset, which allows me to account for firm-specific markups variation, together with firms' characteristics.

Moreover, recent works focus on the long-run *trend* of markups. De Loecker and Eeckhout (2017) document the behaviour of markup over time for the US economy since 1950. They find an increasing trend in the markup. My findings for Belgian manufacturing sector go in the opposite direction, however, the short length of the sample period considered does not allow for drawing clear conclusions about the overall markup trend. Nevertheless, this different behaviour of Belgian economy with respect to the US economy has been recently pointed out by De Loecker et al. (2018). Analyzing the trend of the aggregate markup using firm-level data, for the entire Belgian economy since 1980, they find a relatively stable markup in the manufacturing sector after early 2000s. Differently from this paper, they do not look at the firms' markups behaviour in the crisis period, however their results about Belgian manufacturing markup's trend broadly corroborate my findings.

Finally, related studies analyzed the *pass-through* of costs into prices. These have been mainly focusing on how exchange rate movements affect domestic prices, as reviewed by Burstein and Gopinath (2014). Recent empirical evidence, provided among others by De Loecker et al. (2016), show that the pass-through of a change in cost is incomplete. Moreover, Berman et al. (2012) provide empirical evidence of firms' pass-through heterogeneity. Using French firm-level data, the authors find that highly productive firms react to a depreciation, by increasing their markup by more than less productive firms, resulting in more incomplete pass-through. My contribution to these works consists in providing new empirical evidence about firms' reactions to a positive cost shock, triggered by the financial crisis. An increasing response of the Belgian markup to a positive cost shock could be seen as evidence pointing out a "super complete" pass-through. However, I show by means of a model that this framework contradicts the evidence of a lower markup for less financially constrained firms. I show that it is possible to reconcile the incomplete pass-through hypothesis to the empirical evidence, by introducing a demand shifter, such as firms' quality adjustment. Moreover, I also contribute to the literature about pass-through heterogeneity, by showing that highly financially constrained firms increase the markup by more in response to a cost increase, triggered by the financial crisis.

Theoretical Studies

Several studies have tried to propose different theoretical explanations of markup variations. However,its determinants are not yet fully clear[14]. Particularly, there exist four main theories predicting an increase of markups during recession, hence generating a countercyclical markup. First, the New Keynesian literature, assuming constant markups, generate markup countercyclicality by means of exogenous price stickiness, without the possibility to isolate the effects of markups from those of nominal frictions. Second, the customer market theory in presence of capital market imperfections illustrates that during recessions, financially constrained firms find it optimal to maintain or increase prices to boost cash flow, cutting investment in market share, and thus generating countercyclical markup (Chevalier and Scharfstein (1996), and more recently Gilchrist et al. (2017)). Third, the implicit collusion theory predicts that in oligopoly, during periods of high demand, firms are more tempted to deviate from collusion and steal market share. As a result, the collusive price must adjust downward to eliminate this incentive, producing countercyclical markup (Rotemberg and Woodford (1992)). Finally, the variable entry theory envisions the markup variation as the result of pro-cyclical firms market entry (e.g. Devereux et al.

[14] "How markups move, in response to what, and why, is however nearly terra incognita for macro... [W]e are a long way from having either a clear picture or convincing theories, and this is clearly an area where research is urgently needed." Blanchard (2009)

(1996) and more recently the dynamic model of endogenous markup by Bilbiie et al. (2012)). My contribution with respect to this part of the literature consists in building a parsimonious model of monopolistic competition, with endogenous markup, endogenous quality choice and heterogeneity of firms with respect to cost, which is able to rationalize the empirical evidence.

The closest paper to mine is the one by Altomonte et al. (2017). They also investigate the role of firms' financial conditions for markups. The authors propose a model that incorporates heterogenous financially constrained firms, à la Manova (2012), in a model of variable markup, as in Melitz and Ottaviano (2008). Moreover, they test their theoretical propositions empirically for manufacturing firms, during the recent financial crisis in Austria, France, Germany, Hungary, Italy, Spain, and the United Kingdom. My work differs from the previous one along three dimensions. First, I focus on the Belgian manufacturing sector, using an extensive dataset from the National Bank of Belgium, that covers both small and large firms. Second, I interpret the financial crisis as an increase in the cost of procuring inputs, hence increasing firms' relative marginal cost, as in Christiano et al. (2015). Third, my model differs from the one proposed by Altomonte et al. (2017) because I use additive separable preferences with endogenous quality choice, that allows me to rationalize the empirical evidence. In fact, while Altomonte et al. (2017)'s model predicts that tighter financial conditions lower the markups, my findings clearly indicate an opposite behavior.

4 Conclusion

This paper documents firms' markup behaviour in the aftermath of the financial crisis, by means of firm-level data on Belgian manufacturing sector. Overall, firm-level markups increased and the effect was stronger for more financially constrained firms. Borrowing from the industrial organization and the international trade literature, this paper lays out the theoretical challenges and proposes a conceptual structure, differently framed with respect to the literature, that helps in rationalizing the empirical findings. I first show that standard heterogeneous-firm models, featuring monopolistic competition and variable markups, are unable to replicate these empirical patterns. Then, I introduce endogenous demand shifters that respond to firm investment in market share (e.g. advertising, quality) along the lines of Antoniades (2015) and show that it can explain the observed patterns in firms' markups.

In the aftermath of the 2008 financial crisis, firms faced an increase in the cost of procuring inputs, which raised their marginal cost. To offset this, they decreased their investment in market share, thus adjusting their markups upward. If the firm was characterized by a high level of financial constraint, it experienced more difficulties in procuring inputs than the less constrained firms. The presence of financial frictions amplified the mechanism, leading to a bigger increase in firms markup during the downturn.

This framework could be expanded in at least two directions. First, by incorporating firm-level data on prices, I could perform a micro-to-macro exercise. This would lead to a better understanding of inflation dynamics. Second, I could empirically verify whether in the aftermath of the financial crisis, firms decrease quality as predicted in my model. This analysis could be performed using unit values, as has been done in the international trade literature to measure quality, e.g. Schott (2004). Given the flexibility of the model, and the significant amount of available data, it would be possible to pursue these two research directions both on the aggregate economy and in sector-wise studies.

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Appendix

Table 1: Summary Statistics

			Percentiles		
	Mean	St. Dev.	5th	50th	95th
y	9.82	1.69	7.54	9.56	12.99
l	2.34	1.43	0.26	2.17	4.97
m	9.52	1.81	7.06	9.28	12.89
k	8.03	1.94	4.86	8.07	11.19

Note: The table shows the mean, the standard deviation, the 5th, the 50th and the 95th percentiles of the logarithmic transformation of the data used in the markup estimation: log output, y, log labour, l, log material, m, log capital, k.

Table 2: Markup Estimates - Summary Statistics

broad	N	mean	p50	St. Dev.	p5	p95
1012	29139	1.23	1.21	.29	.83	1.71
1315	12200	1.19	1.11	.33	.81	1.84
1618	24332	1.151	1.11	.29	.75	1.70
2021	6324	1.15	1.12	.19	.89	1.51
2223	17241	1.17	1.16	.22	.85	1.57
2425	34387	1.12	1.07	.33	.69	1.68
2600	3760	1.27	1.16	.38	.83	2.04
2700	3599	1.05	1.06	.20	.71	1.37
2800	10427	1.10	1.07	.22	.79	1.52
2930	3294	1.09	1.06	.22	.79	1.52
3133	14556	1.18	1.13	.31	.80	1.73
Total	159259	1.16	1.12	.29	.78	1.68

Note: On the rows there are the sectors classified by a broad of NACE-BEL REv.2 two-digit sectors. *1012* food products, beverages and tobacco products (NACE 10, 11, 12), *1315* textiles, wearing apparel and leather products (NACE 13, 14, 15), *1618* wood and paper products, and printing(NACE 16, 17, 18), *2021* chemicals and chemical products and basic pharmaceutical products and pharmaceutical preparations (NACE 20, 21), *2223* rubber and plastics products, and other non-metallic mineral products (NACE 22, 23), *2425* basic metals and fabricated metal products, except machinery and equipment (NACE 24, 25), *2600* computer, electronic and optical products (NACE 26), *2700* electrical equipment (NACE 27),*2800* machinery and equipment n.e.c. (NACE 28), *2930* transport equipment (NACE 29, 30), 3133 furniture, other manufacturing, repair and installation of machinery and equipment (NACE 31, 32, 33).We exclude sector NACE 19 coke and refined petroleum products.

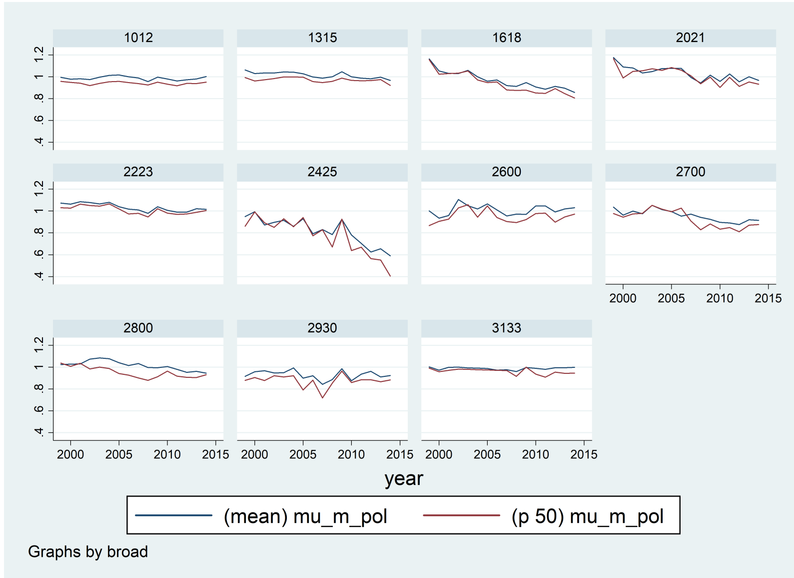

Figure 4: Markup weighted distribution over time, by sectors. Note: The figure shows the mean and the median of the markup distribution over time, weighted by market share, for the sample 1999-2014 by sector broad classification. The shaded area represents the recession period.

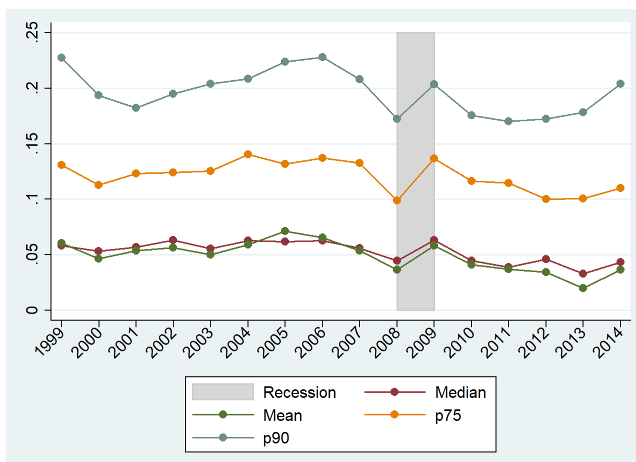

Figure 5: Price cost margin weighted distribution. The price cost margin is computed as the ratio of the difference between sales and variable costs to sales. In this plot material expenditures is the variable cost considered.

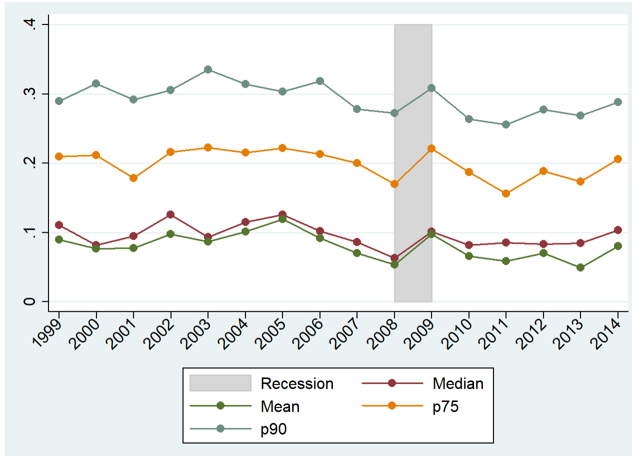

Figure 6: Price cost margin weighted distribution. The price cost margin is computed as the ratio of the difference between sales and variable costs to sales. In this plot I include as variable costs both material expenditures and labor costs.

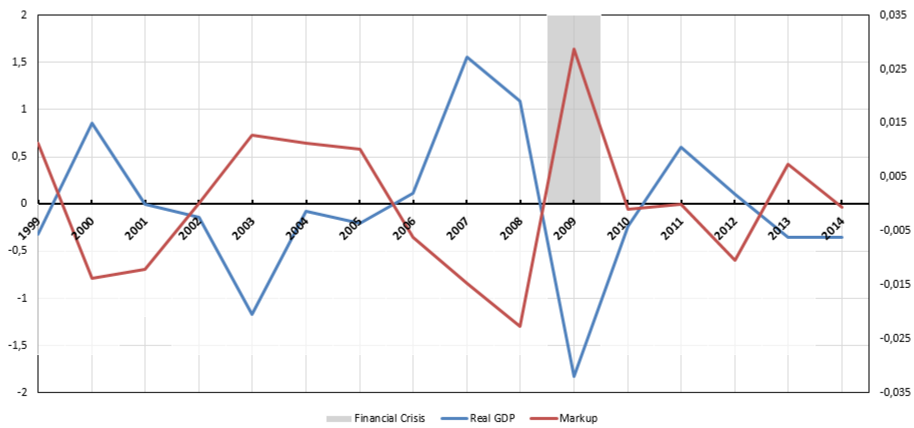

Figure 7: Markups' cyclicality.

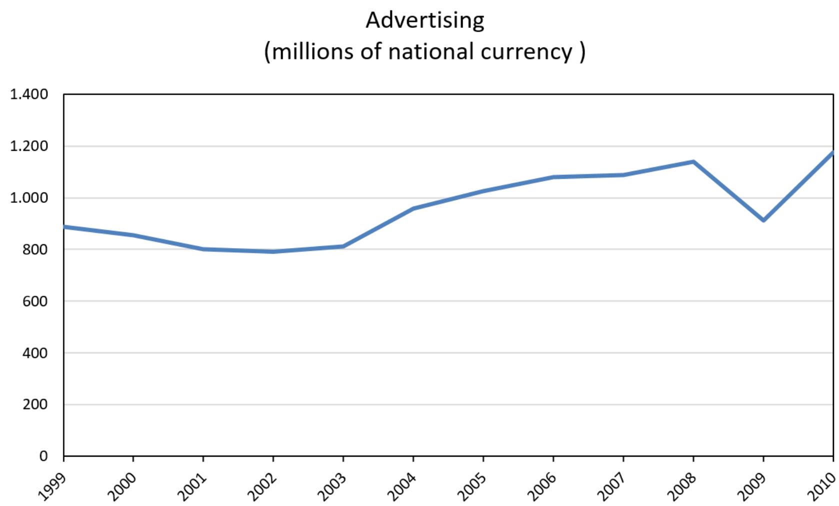

Figure 8: Fims' expenditures in Advertising, in Belgian manufacturing sector over the period 1999-2010.