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## Estimating the New Keynesian Phillips Curve for Italian Manufacturing Sectors

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**Estimating the New Keynesian  
Phillips Curve for Italian  
Manufacturing Sectors**

Carla Massidda

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KTHC - Knowledge, Technology, Human Capital

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# **Estimating the New Keynesian Phillips Curve for Italian Manufacturing Sectors**

## **Summary**

The purpose of this paper is to test the general validity of the NKPC provisions for the Italian manufacturing industries. In particular we are interested in estimating the extent to which the degree of nominal inertia and the fraction of backward-looking price-setters differ from industry to industry. We attempt to address this issue by testing three different model specifications: a pure forward-looking model versus a hybrid model where an income labour share marginal cost measure is considered, and a modified hybrid model specification where marginal costs are corrected to include intermediate inputs. Our results show that the backward-looking component is statistically significant and quantitatively large for all industries. Moreover, this estimate does not depend on the model's specification. Conversely, the parameter measuring the extent of price rigidity is sensitive to the definition of firms' cost. Interpreting the overall results, we conclude that price-setting behaviour is not totally homogeneous among Italian firms.

**Keywords:** Phillips curve, Inflation, Unit labour cost

**JEL Classification:** E3

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# Estimating the New Keynesian Phillips Curve for Italian Manufacturing Sectors

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## Abstract

The purpose of this paper is to test the general validity of the *NKPC* provisions for the Italian manufacturing industries. In particular we are interested in estimating the extent to which the degree of nominal inertia and the fraction of backward-looking price-setters differ from industry to industry. We attempt to address this issue by testing three different model specifications: a pure forward-looking model versus a hybrid model where an income labour share marginal cost measure is considered, and a modified hybrid model specification where marginal costs are corrected to include intermediate inputs. Our results show that the backward-looking component is statistically significant and quantitatively large for all industries. Moreover, this estimate does not depend on the model's specification. Conversely, the parameter measuring the extent of price rigidity is sensitive to the definition of firms' cost. Interpreting the overall results, we conclude that price-setting behaviour is not totally homogeneous among Italian firms.

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## 1 Introduction

The existence of possible sectoral asymmetries in firms' pricing behaviour and in the degree of nominal price stickiness represents a central question in economics and is a particularly pertinent issue in current studies on inflation control. In this context, relative prices are often used as a measure of "supply shocks" in Phillips curve equations that seek to model the short run output-inflation trade-off. However, it is still not obvious how changes in relative price affect aggregate inflation nor how relative price is related to supply shocks. According to Aoki (2001) and the new-Keynesian view<sup>1</sup>, only in a sticky-prices environment

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<sup>1</sup>Goodfriend and King (1997), Rotemberg and Woodford (1997), Clarida et al. (1999), Eceg et al. (2000), Christiano et al. (2001), Dotsey and King (2001).

with different degrees of inertia characterising the different sectors, can a structural link between relative-price changes and aggregate permanent inflation be formally derived.

Despite of this, a multi-sector analysis of pricing behaviour and optimal monetary policy is rather limited and it lacks of conclusive evidence. There are, however, some considerable exceptions highlighting two main approaches utilised by researchers in this field. One is to ask private agents themselves how they set prices and would respond to particular events. This kind of evidence has been provided by Bils and Klenow (2002) for the U.K., Hall and Walsh (2000) for the USA and Fabiani and Gatulli (2004) for Italy. Accordingly, some interesting asymmetries in nominal inertia in various sectors and in the responsiveness of firms' price to shocks have been detected.

Another approach is to collect data on economic outcomes and infer price-stickiness from real/nominal correlations. The empirical analysis undertaken as part of this approach draws on the work of Aoki (2001), Bartsky et al. (2003) and Erceg and Levin (2002). As a whole, these works, although an important step forward in sectoral interdependency analysis, still fail to explore a multi-sector environment.

In this sense, Leith and Malley (2003) offer an important contribution. Using the insight of the new-Keynesian approach, they extend the original model to take sectoral differences in price setting behaviour into account. In particular, in their work a *New Keynesian Phillips Curve* sectoral relationship is formally derived by allowing firms in one sector to buy goods from other firms. More precisely, they construct a model of firms' price-setting behaviour which allows firms to sell their products to consumers, the government and other firms and to substitute intermediate goods for labour in production. In so doing, they allow for variations in raw materials and intermediate goods prices affecting the marginal cost faced by a price-setter. Then, as suggested by Galì and Gertler (1999), Galì et al. (2001) and Sbordone (2002) at aggregate level, they insert their new intermediate input-based marginal cost measure into their sectoral-*NKPC* relationship as the variable driving inflation dynamics. Furthermore, keeping in following Galì and Gertler (1999) and Galì et al. (2001), they relax the pure forward-looking assumption, admitting the existence of rules of thumb within the model.

In the same spirit as this recent literature on inflation dynamics, this paper attempts to provide new empirical evidence on Italian manufacturing firms' pricing behaviour within a *NKPC* framework. In particular, we are interested in estimating the extent to which the degree of nominal inertia and the fraction of backward-looking price-setters differs from sector to sector. To accomplish this task we first estimate the forward-looking version of the *NKPC* versus its hybrid formulation considering labour cost as the only variable cost component in our marginal cost measure. This exercise is aimed at testing the general relevance of the backward-looking component for each industry. Then we go a step further focusing our attention on the role of material costs in determining the degree of price stickiness for each sector. In the light of this, we correct our measure of marginal cost to take intermediate inputs into account and estimate

the corrected *NKPC* as derived by Leith and Malley.

Following the prevailing empirical literature on this subject, we implement a *GMM* estimation of the *NKPC* for eight branches of the Italian manufacturing sector.

Our results show that the backward-looking component is statistically significant and quantitatively large for all industries. Moreover, this estimate does not depend on the model's specification. Conversely, the parameter measuring the extent of price rigidity is sensitive to the definition of firms' cost. All in all, we conclude that price-setting behaviour is not completely homogeneous among Italian firms.

The remainder of the paper is organised as follows. Section 2 develops the theoretical model used for estimation. Section 3 contains the empirical analysis. Finally, section 4 draws conclusions.

## 2 The theory

### 2.1 The general specification of marginal cost based NKPCs

The New Keynesian model's basic theoretical framework takes into consideration a *continuum* of monopolistically competitive firms, uniformly distributed on a unit interval. Each firm, indexed by  $z \in [0, 1]$ , produces at time  $t$  a differentiated good  $Y_t^z$  whose price is  $P_t^z$ . Firm  $z$  faces a downward-sloping isoelastic demand curve  $Y_t^z = D \left( \frac{P_t^z}{P_t} \right)^{-\varepsilon} Y_t$  for its product, where  $P_t$  and  $Y_t$  are respectively the aggregate price and output level. The same firm produces according to a Cobb-Douglas (*CD*) production technology  $Y_t^z = (K_t^z)^\alpha (A_t N_t^z)^{1-\alpha}$  where  $K_t^z$  and  $A_t N_t^z$  are, respectively, the  $z$ -th firm's capital and effective-labour augmenting requirements. Since we are in a constant-returns-to-scale environment,  $\alpha \in [0, 1]$ . In this context, profits maximising firms are not totally free in setting nominal price. In particular, a Calvo-type (1983) constraint is assumed: each firm faces a constant probability  $(1 - \theta)$  of adjusting its price in any given period, and such probability is assumed to be independent of previous price adjustments. It follows that, the expected period during which a firm's price can remain unchanged is given by the ratio  $D = \left( \frac{1}{1-\theta} \right)$ .

Consequently, the evolution of the price level ( $p_t$ ) turns out to be expressed (in log term) as follows (Galí and Gertler, 1999):

$$p_t = (1 - \theta)p_t^* + \theta p_{t-1}$$

where ( $p_t^*$ ) is the new price. Under the assumed technology and demand conditions, an optimising firm sets its  $p_t^*$  by fixing a markup over a discounted stream of expected future nominal marginal cost<sup>2</sup>. The log-linear approxima-

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<sup>2</sup>All firms that alter prices in period  $t$  choose the same optimal price.

tion (around a steady state, characterised by zero inflation and flexible price equilibrium) of this firm's optimal pricing rule can be expressed as:<sup>3</sup>

$$(1) \quad p_t^* = \log \mu + (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left\{ mc_{t,t+k}^n \right\}$$

where  $\beta$  is the subjective discount rate,  $mc_{t,t+k}^n$  is the logarithm of the nominal marginal cost in a particular period  $t+k$  of a firm that last reset its price in period  $t$  and  $\mu \equiv \varepsilon/(\varepsilon - 1)$  is the firm's desired markup.

In this arrangement, aggregating individual firms' decision leads to a verifiable trade-off between inflation and real marginal cost that turns out to be very useful in understanding inflation dynamics. Here the problem is that empirical implementation of such a relation raises some critical issues. As it is well known, it is impossible to observe real marginal costs at firm-level. It therefore follows that the empirical implementation of the model requires a substitute for this unobservable cost component. The normal procedure is to use average aggregate marginal cost instead of the unobservable cost component. Considering labour markets competitive, this "aggregation process" can be carried out according to two alternative assumptions regarding capital input. We can, in fact, assume that capital can be instantaneously reallocated from one firm to another, so as to equate the shadow price of capital services at all times<sup>4</sup>. If this is the case, all firms will be facing the same real marginal cost.<sup>5</sup> We know, however, that this is quite an extreme assumption, unlikely to correspond to reality.

On the contrary, according to Sbordone (2001), it can be assumed that firms' relative capital stocks do not vary with their relative prices or relative product levels. Thus, firms charging different relative prices will have different sales levels and hence different marginal cost levels. It follows that marginal costs are an increasing function of the firm's output level and, therefore, of the firm's relative price. Based on this assumption, Galì *et al.* (2001) found that the relationship between the real marginal cost of the firm that optimally sets price at  $t$  and the corresponding average aggregate cost component can be expressed as follows:<sup>6</sup>

$$(2) \quad mc_{t,t+k} = mc_{t+k}^{avg} - h(p_t^* - p_{t+k})$$

where  $mc_{t+k}^{avg}$  is defined as the log deviation of average real marginal cost at time  $t$  from its steady-state and  $h = \left(\frac{\varepsilon\alpha}{1-\alpha}\right)$  is the aggregation factor (depending on technology curvature and on demand elasticity) which allows us to define the unobservable firm-level marginal cost in terms of the observable average aggregate marginal cost, when this cost component differs from one firm to

<sup>3</sup>Cf. Galì and Gertler (1999), Galì et al. (2001), Gagnon and Khan (2001) and Sbordone (2001).

<sup>4</sup>See, *inter al.* Yun (1996) and Goodfriend and King (1997).

<sup>5</sup>Under constant return to scale firms face identical constant marginal costs (Galì *et al.*, 2001: 1234).

<sup>6</sup>Practically the same algebra is found in Gagnon and Khan (2001).

another. In equation (2), the term in parenthesis may be interpreted as firm  $z$ 's relative price.

By substituting expression (2) in firm  $z$ 's optimal pricing rule the following forward-looking formulation of the cost-based *NKPC* can be derived:

$$(3) \quad \pi_t = \beta E_t \{ \pi_{t+1} \} + \lambda mc_t^{avg}$$

where  $\pi_t$  is the inflation rate,  $\lambda \equiv \left( \frac{(1-\theta)(1-\beta\theta)}{\theta} \right) \xi$  and  $\xi = \frac{1-\alpha}{1+\alpha(\varepsilon-1)} = \frac{1}{1+h}$ .

Within the same formulation, the model in Eq(3) was extended by Galí and Gertler (1999) in order to relax the rational expectations assumption. In so doing, they introduced a backward-looking component which allows a fraction  $\omega$  of firms to set their prices following a non optimal rule-of-thumb<sup>7</sup>. In the presence of this rule-of-thumb, Benigno and Lopez-Salido (2002) proposed, as a better approximation of price inertia duration, the new index  $D^H = \frac{1}{1-\theta} \frac{1}{1-\omega}$ .<sup>8</sup>

The new so-called "hybrid" formulation of the *NKPC* takes the following form:

$$(4) \quad \pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \{ \pi_{t+1} \} + \tilde{\lambda} mc_t^{avg}$$

where  $\tilde{\lambda} \equiv \left( \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\phi} \right) \xi$ ,  $\phi \equiv \theta + \omega [1 - \theta (1 - \beta)]$ ,  $\gamma_b \equiv \omega \phi^{-1}$  and  $\gamma_f \equiv \beta \theta \phi^{-1}$ .

Equations (3) and (4) now have the appeal of expressing inflation in terms of observable measures, thus proving to be suitable for empirical analysis. The observable measure which is generally chosen to represent average real marginal cost is provided by real unit labour cost or labour income share ( $RMC_t = \frac{(W_t/Y_t)}{(1-\alpha)(P_t/N_t)}$ ). It follows that  $mc_t^{avg}$  in equations (3) and (4) can be proxied by the  $\hat{s}_t$  variable, defined as the log deviation of labour income share ( $S_t$ ) from its sample mean  $\bar{S}$ . However, as discussed by Rotemberg and Woodford (1999), if other technologies are considered, such a measure is inappropriate. As a matter of fact, estimates of price-setting behaviour grounded on the labour income share-based measure of marginal costs may suffer from a misspecification bias. This happens, for instance, when inputs other than labour force vary with production, even in the short run. In this case, sectoral interdependencies should be explicitly included within a complete theoretical model and material cost should appear as argument of the production function.

The model presented in the present section lacks of both components.

## 2.2 A multi-sector NKPC specification

The theory presented in the above section models aggregate price-setting behaviours in a single sector environment and consider labour input as the only

<sup>7</sup>Cf. Fuhrer-Moore (1995, 1997) and Robert (1999, 2001).

<sup>8</sup>They observe: among firms facing the probability  $(1-\theta)$  of changing their prices, only the fraction  $(1-\omega)$  follows an optimal rule; therefore, in the hybrid model, the total fraction of agents that keeps prices fixed is expressed by  $\omega + (1-\omega)\theta$ . The expression  $(1-\omega)\theta$  measures the fraction of firms that behave in a forward-looking manner, but cannot adjust their price.



variable cost component. Following this literature, Leith and Malley (2003) extended the Galí and Gertler's single-sector hybrid *NKPC* and constructed a new environment where firms' price-setting behaviour takes into account the sectoral composition of a domestic economy. It follows that material input plays a relevant role in the determination of firms' marginal cost.

Leith and Malley assume that imperfectly competitive firms sell their goods to buyers who purchase goods from all sectors in the economy. It follows that relative prices assume a central role in determining firms' optimal pricing decisions. Again, a Calvo-type (1983) constraint limiting the frequency of price adjustment is assumed within the model.

The buyers of each firm's goods are consumers, the government and other firms so that the demand for firm  $z$ 's product within a specific sector  $i$  is represented by:

$$(5) \quad y(i, z)_t = \left(\frac{p_t(i, z)}{P_t^i}\right)^{-\epsilon_i} (c(i)_t + g(i)_t + m(i)_t)$$

where  $\left(\frac{p_t(i, z)}{P_t^i}\right)$  is firm's  $z$  price ( $p_t(i, z)$ ) relative to the prices of other producers in its sector ( $P_t^i$ ),  $c(i)_t$  and  $g(i)_t$  are the respective amounts of private and public consumption, and  $m(i)_t$  is the demand for the basket of products produced in sector  $i$  for use as an intermediate input in the production of all firms in the economy.

The same firm  $z$  produces according to a Constant elasticity of substitution (*CES*) production function of the following type:

$$(6) \quad y(i, z)_t = (\alpha_{H,i} H(i, z)_t^{\frac{\rho_i-1}{\rho_i}} + \alpha_{m,i} (m_t^{i,z})^{\frac{\rho_i-1}{\rho_i}})^{\frac{\rho_i-1}{\rho_i-1/\psi_i}} \bar{K}_i^{1-\frac{1}{\psi_i}}$$

where  $\bar{K}$  is the firm  $z$ 's fixed capital stock weighted by the term  $(1 - \frac{1}{\psi_i})$ ,  $H(i, z)_t$  is the quantity of workers in sector  $i$  used in the production by the same firm and  $m_t^{i,z}$  is a *CES* aggregate of the intermediate goods produced by other firms and used in production by firm  $z$  in sector  $i$ . In the model, variable inputs are assumed as being imperfect substitutes so as  $\rho_i$  in Eq. (6) measures the elasticity of substitution between them.

Considering the presence of two variable inputs, real marginal cost is defined as follows within this model:

$$(7) \quad MC(i, z)_t = \frac{W_t^i}{P_t} \frac{\delta H(i, z)_t}{\delta y(i, z)_t} + \frac{P_t^{m,i}}{P_t} \frac{\delta m_t^{i,z}}{\delta y(i, z)_t}$$

where  $W_t^i$  is the wage rate in industry  $i$  and  $P_t^{m,i}$  is defined as a price index associated with the use of intermediate goods in production in sector  $i$ . Again, the aim is to find an expression for  $MC(i, z)_t$  in terms of observable variables. After substituting cost minimisation conditions for labour and intermediate goods in the production function, an expression for the optimal level of  $H(i, z)_t$  and  $m_t^{i,z}$  can be derived.<sup>9</sup> These two relationships can be exploited

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<sup>9</sup> See Eq. (14) and (15) in Leith and Malley (2003)

to obtain the two partial derivatives  $\frac{\delta H(i,z)_t}{\delta y(i,z)_t}$  and  $\frac{\delta m_t^{i,z}}{\delta y(i,z)_t}$  which can be inserted into Eq.(7).

After their insertion, real marginal cost equals:

$$(8) \quad MC(i, z)_t = (y(i, z)_t)^{\psi_i - 1} \widehat{MC}_t^i$$

where  $\widehat{MC}_t^i = \frac{W_t^i}{P_t} (\alpha_{H,i} + \alpha_{m,i} (\frac{W_t^i}{P^{m,i}} \frac{\alpha_{m,i}}{\alpha_{H,i}})^{\rho_i - 1})^{\frac{-\rho_i}{\rho_i - 1}} + \frac{P^{m,i}}{P_t} (\alpha_H (\frac{W_t^i}{P^{m,i}} \frac{\alpha_{m,i}}{\alpha_{H,i}})^{\rho_i - 1} + \alpha_{m,i})^{\frac{-\rho_i}{\rho_i - 1}}$ .

Eq.(8) can be inserted into the firm's  $z$  profit maximising problem and then the evolution of the optimal price set by this profit-maximising firm can be derived as a function of marginal cost.

Aggregating firms' behaviour and considering that some firms do not follow an optimisation rule (but rather a rule of thumb), after doing some algebra<sup>10</sup> the expression of Leith and Malley's multi-sectoral modified Phillips curve can be derived. In what follows we present the version of this curve which is appropriate for estimation:

$$(9) \quad \pi_t^i = \gamma_b^i \pi_{t-1}^i + \gamma_f^i E_t \{ \pi_{t+1} \} + \left( \frac{(1-\omega^i)(1-\theta^i)(1-\beta\theta^i)}{\phi^i} \right) \frac{1}{1+(\psi^i-1)\epsilon^i} \widehat{mC}_t^i$$

where the term  $\widehat{mC}_t^i$  corresponds to the following expression

$$\widehat{mC}_t^i = \frac{\overline{W^i H^i}}{\overline{W^i H^i} + \overline{P^{m,i} m^i}} \widehat{mC}_t^i + \rho^i \frac{\overline{W^i H^i}}{\overline{W^i H^i} + \overline{P^{m,i} m^i}} \left( 1 - \frac{\overline{W^i H^i}}{\overline{W^i H^i} + \overline{P^{m,i} m^i}} \right) \widehat{w}_t^{i,m} + \left( 1 - \frac{\overline{W^i H^i}}{\overline{W^i H^i} + \overline{P^{m,i} m^i}} \right) \widehat{P}_t^{m,i} + (\psi^i - 1) \widehat{y}_t^i.$$

In that expression all hatted variables correspond to deviations from the steady-state:  $\widehat{mC}_t^i$  is the deviation in the ratio of labour costs to gross output,  $\widehat{w}_t^{i,m}$  is the deviation in the wage rate deflated by the price of material in industry  $i$  ( $\widehat{W}_t^i - \widehat{P}^{m,i}$ ),  $\widehat{P}_t^{m,i}$  is the deviation in the price of materials deflated by the output price of industry  $i$  ( $\widehat{P}^{m,i} - \widehat{P}_t^i$ ) and  $\widehat{y}_t^i$  is the deviation in gross output.

As specified in Eq.(9), Leith and Malley's Phillips curve perfectly compares to the model highlighted in the previous section and, if no intermediate goods are used in production, the former and the latter coincide perfectly.<sup>11</sup>

### 3 Empirical evidence

The main purpose of our empirical analysis is to test the general validity of the *NKPC* predictions for the Italian manufacturing industries. In particular we are

<sup>10</sup> As it is common, the log-linearised index of output prices in sector  $i$  has to be inserted into the log-linearised equation describing the evolution of the optimal price set by profit-maximising firms.

<sup>11</sup> "[...] If no intermediate goods are used in production then this reduces to the Phillips curve employed in, for example, Galí et al. (2001). [...]". (Leith and Malley, 2003: 12).

interested in estimating the extent to which the degree of nominal inertia and the fraction of backward-looking price-setters differs from industry to industry. To accomplish this task, we first test predictions of the pure forward-looking model of Eq.(3) against those of the hybrid model expressed in Eq.(4). As we explained in the previous section, the empirical results obtained with these estimates may suffer from a misspecification bias since these models totally ignore the existence of sectoral interdependencies within a domestic economy. Nevertheless, this exercise is useful for the purpose of this paper, as it is mainly aimed at testing the *NKPC*'s general performance. Structural estimates of equations (3) and (4) are alternatively conducted under hypotheses of both  $\xi^i = 1$  and  $\xi^i \neq 1$ .

We then go on to estimate structural parameters of the *NKPC* when intermediate input costs are considered into the definition of the equation to be estimated. In detail, to illustrate the potential importance of material input costs, we first repeat regress of Eq.(4), redefining marginal cost by taking into account the cost of materials. Finally, we estimate structural parameters of the model presented in Eq.(9) which is correctly defined in order to take sectoral interdependencies into account.

For simplicity of exposition, we will refer to *M1* as the reduced-form estimate of Eq.(3), to *M2* as the structural estimate of Eq (3) when  $\xi^i = 1$ , to *M3* as the structural estimate of Eq.(4) when  $\xi^i \neq 1$ , to *M4* as the structural estimates of Eq.(4) when  $\xi^i = 1$ , to *M5* as the structural estimates of Eq.(4) when  $\xi^i \neq 1$  and, finally, to *M6* as the structural estimates of Eq.(9).

As an econometric procedure, we implement Hansen's (1982) Generalised Method of Moment (*GMM*, hereafter) which easily handles the set of orthogonality conditions that, under *RE*, can be derived from equations (3), (4) and (9).

The data we use are value added, labour income, unit labour costs, inflation, intermediate inputs and price indexes. We implemented *GMM* with lagged variables for inflation, detrended output, real marginal cost and wage inflation as instruments. Standard errors on estimated parameters are modified using the Newey-West correction. To test the model's overidentifying restrictions, we performed Hansen's test based on the J-statistic.

### 3.1 Labour share based marginal cost measure

#### 3.1.1 Reduced form estimates

We begin by presenting *GMM* non structural estimates of Eq.(3). The set of orthogonality conditions is as follows:

$$E_t \{ (\pi_t^i - \beta^i \pi_{t+1}^i - \lambda^i mc_t^i) z_t^i \} = 0$$

where  $z_t^i$  denotes a vector of variables observed at time  $t$ .

Results are summarised in Table 2, where we report the point estimate of the discount factor and the slope coefficient on marginal cost. Results regarding

the model's overidentifying restrictions test (J-statistic) are reported as well. The empirical model works reasonably well: as implied by the theory, the slope coefficient is positive and significantly different from zero for 6 industries out of 8. We have problems only for industry n°8 (the  $\lambda$  coefficient exhibits the wrong sign) and for industry n°11 (the same coefficient is not significantly different from *zero*). Finally, the estimate of the discount factor is a bit low; this is especially true for sectors 6, 7, 9 and 11.

### 3.1.2 Forward-looking model structural estimates

We now go on to the structural estimate of the model in Eq.(3). In this case, previous empirical works have proved that *GMM* results may be sensitive to the specification of orthogonality conditions<sup>12</sup>. Taking this into consideration, we chose the following specification:

$$E_t \{ (\pi_t^i - \beta^i \pi_{t+1}^i - \theta^{i-1} (1 - \theta^i) (1 - \beta^i \theta^i) \xi m c_t^i) z_t^i \} = 0$$

which, according to Galì *et al.* (2001), produces more reasonable estimates of structural parameters.

The restrictions imposed by the model imply that we can estimate only two parameters. We have chosen to estimate the main structural parameters  $\theta^i$  and  $\beta^i$  conditional on a set of plausible values imposed for  $\alpha^i$  and  $\varepsilon^i$ . These values can be derived from information on the steady-state (average) markup levels  $\mu^i$  and the labour income share,  $\bar{S}^i$ . In fact, simple algebra<sup>13</sup> shows that  $\alpha^i = 1 - \bar{S}^i \mu^i$ , whereas, by definition,  $\varepsilon^i = \mu^i / (\mu^i - 1)$ .

As we know, average markup and labour income share may differ among firms; for our work, this implies calibrating each industry separately [see Table 3].

As far as the calibration of average markup is concerned, we consider a study by Marchetti (1999) where markup values are estimated at branch level for the manufacturing sector as a whole.<sup>14</sup> Table 3 (column 1) reports these values. For calibrating  $\bar{S}^i$ , we use information on the average labour income share. These values are also reported in Table 3 (column 2).

Once values of  $\mu^i$  and  $\bar{S}^i$  are fed into the equations defining measures of  $\alpha^i$  [Table 3, column 3] and  $\varepsilon^i$  [Table 3, column 4], these two parameters are used to derive a value for the constant  $\xi^i$  [Table 3, column 5]. Recall that  $\xi^i$  falls to one when all firms are facing the same real marginal cost.<sup>15</sup>

Table 4 reports estimates of Eq.(3) conditional on the two possible values of the constant  $\xi^i$ . The first two columns in the Table give the estimated values of the primitive parameters  $\beta^i$  and  $\theta^i$ ; the third and the fourth highlight the

<sup>12</sup>Galì *et al.* (2001).

<sup>13</sup>By definition, average markup equals the inverse of the average *RMC*. Since  $RMC^{avg} = \frac{1}{1-\alpha} S$ , it follows that  $\alpha = 1 - \bar{S} \mu$ .

<sup>14</sup>In fact, this study reveals that for the Italian manufacturing sectors the perfect competition is rejected.

<sup>15</sup>Under constant return to scale firms face identical constant marginal costs (Galì *et al.*, 2001: 1234).

values derived for  $\lambda^i$ , for  $D^i$  and, finally, the last column highlights the results of overidentifying restriction tests.

The general fit of the model appears reasonably good; the model's overidentifying restrictions are not rejected and the main New Keynesian hypothesis on the role of *RMC* in driving inflation dynamics at the industry level is confirmed. Coefficients always appear to be of the correct sign and significantly different from zero.

For a more detailed analysis of the results reported in Table 4, three main features are worth noting.

First, estimates of  $\beta^i$  are quite stable and very reasonable for all specifications (plausible values are considered those close to 0.99); the discount rate shows excessively low values only in *M2* of sector n° 6, in *M3* of sector n° 10 and in *M2* of sector n° 11.

Second, alternative assumptions on the constant  $\xi^i$  affect the estimate of parameter  $\theta^i$ , which measures the extent of price rigidity. According to Galì *et al.*'s (2001) imposing the assumption of constant return to scale ( $\xi^i = 1$ ), we should get higher estimates of the parameter  $\theta^i$ ; we can confirm this finding for sectors n° 8, 9, 10, 11 and 13.

Third, the stickiness parameter  $\theta^i$  differs from branch to branch, denoting the presence of branches where price inertia appears a more important phenomenon with respect to others. It follows that the implied measure of the average time prices remains unchanged,  $D^i$ , varies as well. We get degrees of prices stickiness which range between 3.2 and 9.1 quarters when we estimate *M1* and between 1.7 and 6.25 quarters when we estimate *M2*.

### 3.1.3 Hybrid model structural estimates

Extending the approach in the previous section, we now estimate the hybrid model of Eq.(4). The orthogonality conditions are now specified as follows:

$$E_t \{ (\pi_t^i - \omega^i \pi_{t-1}^i - \beta^i \theta^i \pi_{t+1}^i - \phi^{i-1} (1 - \omega^i) (1 - \theta^i) (1 - \beta^i \theta^i) \xi^i m c_t^i) z_t^i \} = 0$$

As the hybrid model indicates, we can now estimate the additional parameter  $\omega^i$ , measuring the fraction of backward-looking price setters. As for  $\theta^i$  and  $\beta^i$ , estimates of  $\omega^i$  are conditional on the values imposed for  $\alpha^i$  and  $\varepsilon^i$  and, thus, on the parameter  $\xi^i$ .

Table 5 reports estimates of Eq.(4) dependent on the two possible values that  $\xi^i$  can assume. The first three columns in the Table give the estimated values of the primitive parameters  $\omega^i$ ,  $\theta^i$  and  $\beta^i$ ; the fourth and the fifth highlight the values derived for  $\gamma_b^i$  and  $\gamma_f^i$ ; the sixth and seventh contain derived indexes of price rigidity  $D^i$  and  $D^{iH}$  respectively and, finally, the last column highlights the results of overidentifying restriction tests.

As we can see from the table, the good performance of the model is confirmed and, according to the J-test, the model's overidentifying restrictions are not rejected (with the exclusion of sector 13). It is also evident that  $M4(\xi^i = 1)$

performs better than  $M5(\xi^i \neq 1)$ . In fact, imposing  $\xi^i \neq 1$  yields estimates for the  $\theta^i$  and  $\beta^i$  parameters that are not statistically significant (despite having the right sign), for sectors n° 8, 9, 10 and 11. For sectors n° 7, 12 and 13 we can confirm that imposing the assumption of constant returns to labour ( $\xi^i = 1$ ) yields a higher estimate of the stickiness parameter. Here, again, the main results in the Table are worth noting.

First, the fraction of firms that follow a rule of thumb is quite large and statistically robust. Furthermore, estimates of the parameter  $\omega^i$  are stable in the two different models  $M4(\xi^i = 1)$  and  $M5(\xi^i \neq 1)$  and are economically plausible. It follows that, with the exclusion of industries 9 and 12, the weight on the backward-looking component of inflation,  $\gamma_b^i$ , is almost as large for each industry as that on the forward-looking component,  $\gamma_f^i$ , sometimes being even larger (industries 6, 7 and 10).

Second, here it is confirmed that the points estimate of the  $\theta^i$  parameter varies from one branch to another, so that the implied index of price inertia varies as well. We calculate two versions of this index: the ratio  $D^i = 1/(1 - \theta^i)$  and the ratio  $D^{iH} = 1/(1 - \theta^i)(1 - \omega^i)$ , as suggested by Benigno-L.Salido. According to our results, with the index  $D^{iH}$ , the degree of price inertia increases for all sectors. With respect to results obtained estimating the pure forward-looking model in Eq.(3), we now obtain inertia degrees that are higher for industries 6, 7, 9,13 and lower for industries 10, 11.

Third, the estimate of the discount factor  $\beta^i$  is excessively low.

In conclusion, it appears that the hybrid *NKPC* specification is a plausible framework for describing inflation dynamics in Italian manufacturing industries. Nevertheless, the degrees of price inertia we obtain are undoubtedly unrealistic.

## 3.2 Intermediate input based marginal cost measure

In this section, we determine whether material inputs, when included into the definition of the firms' real marginal cost, influence the point estimates of the principal structural parameters. In the following sub-sections, we first conduct an analysis on the quantitative relevance of material costs; then, as previously anticipated, estimates of equations 4 and 9 will follow.

### 3.2.1 Intermediate input in Italian manufacturing sectors

This section analyses the importance of material costs and the behaviour of relative-price within Italian manufacturing sectors. This analysis is highly subject to the availability of sectoral-level data.

The main problem is related to the availability of adequate material cost and price series. For material cost, we construct our quarterly time series starting from a yearly series of Input/Output (I/O henceforth) tables computed by Rampa (2001) for the Italian economy and expressed in current-price. For each industry  $i$ , we consider material cost to be the amount of goods produced by all industries (industry  $i$  included) and used in production by industry  $i$ .<sup>16</sup>

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<sup>16</sup>In doing this, we had to adapt the classification of the sectors as appearing in the I/O

Once these material cost series are available, our labour force-based marginal cost measure can be corrected in order to include this new cost component. Our new definition of marginal cost is then indicated by the following ratio:

$$MC^{i\text{tot}} = \frac{W^i H^i + P^{m^i} m^i}{P^i Y^i}$$

where the ratio  $\frac{W^i H^i}{P^i Y^i}$  expresses real unit labour costs and  $P^{m^i} m^i$  is material cost at current price.

For the price index series the problem is more serious since material prices are not available. Thus, for each sector  $i$  we approximate this index, calculating an intermediate inputs price index for industry  $i$  ( $P^{m^i}$  of Eq. (7)) defined as a weighted average of sectoral price indexes, where material costs are used as weights. In details, in our index, the price of each industry is weighted by the ratio of material input demanded from this industry by industry  $i$  relative to the total amount of material input used in production by industry  $i$ .

With these data in hand, we can calculate some descriptive statistics which are shown in Table 8. The first column reports the ratio of material costs relative to variable costs; the second reports the ratio of material costs relative to GDP and the third the ratio of labour costs relative to GDP. All ratios indicate that material costs are an important part of the variable costs.

Table 6 - Material costs in Italian manufacturing industries

Sectors	$\frac{P^{m^i} m^i}{W^i H^i + P^{m^i} m^i}$	$\frac{P^{m^i} m^i}{P^i Y^i}$	$\frac{W^i H^i}{P^i Y^i}$	$\mu^i$
6	0.611	0.376	0.309	0.316
7	0.595	0.465	0.398	0.137
8	0.559	0.413	0.424	0.163
9	0.681	0.557	0.270	0.172
10	0.558	0.411	0.370	0.219
11	0.578	0.447	0.386	0.168
12	0.531	0.411	0.405	0.185
13	0.593	0.521	0.368	0.111

According to Domowitz *et al.* (1988), we also calculate the price-cost markup implicit in each industry as the ratio  $\frac{\text{Value added} - \text{Production workers payroll}}{\text{Value added} + \text{Cost of Materials}}$ . The average markup values we obtained are reported in the last column of Table 6 and can be compared with those obtained by Marchetti (1999), used in our calibrations. Interestingly, with the exclusion of industry 6, there are no noticeable differences.

tables to ours (ISTAT).

### 3.2.2 Estimates

We now proceed by estimating structural parameters of the *NKPC* when materials are included in the definition of the firms' real marginal cost.

First, to illustrate the potential importance of material input costs, we repeat the regression of Eq.(4) where our marginal cost measure is re-defined as the ratio of production workers' payroll plus intermediate inputs relative to gross output.

Table 7 reports the main results, displaying two noteworthy features. First, the general fit of the model is good and the relevance of non-rational behaviour is statistically confirmed. The coefficients on inflation and marginal cost are of the correct sign (with the sole exclusion of M5 for sector 12) and statistically significant (only M5 in sectors 8 and 9 they are not statistically different from zero). Second, estimates reported in the Table are again characterised by unrealistic values of the two parameters  $\theta^i$  and  $\beta^i$ , with excessively high estimates for  $\theta^i$  and excessively low ones for  $\beta^i$ .

Given these results, we then carried out a robustness check on the model, analysing how estimates of the model depend on restrictions imposed on  $\beta^i$ . In particular, as implied in the standard hybrid case, we restricted  $\beta^i$  to 1. Table 7*bis* reports the main results, three worthy of note. First, asymmetries in price-setting behaviour from industry to industry now seem a less important phenomenon. Second, estimates of  $\theta^i$ , and therefore of the  $D^i$  and  $D^{iH}$  indexes, become more plausible values. Third, with respect to previous estimates, for many industries the importance of the backward-looking component is slightly reduced.

These latter results, despite of having been obtained in an incomplete theoretical context, are of great interest and give us an important feedback for the rest of our empirical analysis. On the one hand, they confirm that the hybrid model is a reasonable framework for describing sectorial inflation dynamics; on the other hand, they reveal that, restricting  $\beta^i = 1$  yields very realistic and statistically robust estimates of the other structural parameters.

With this important feedback available, we move to the final part of the present study, estimating the hybrid *NKPC* presented in Eq.(9). As detailed in Section 2, this equation describes sectorial inflation dynamics taking into account of the sectoral composition of a domestic economy. With respect to the models specified in Eq.(3) and Eq.(4), here intermediate inputs are explicitly considered in defining the firms' production function, the other inputs being capital and labour.<sup>17</sup>

Similar to previous *GMM* estimates, orthogonality conditions are defined as follows:

$$E_t \left\{ \left( \pi_t^i - \omega^i \pi_{t-1}^i - \beta^i \theta^i \pi_{t+1}^i - \phi^{i-1} (1 - \omega^i) (1 - \theta^i) (1 - \beta^i \theta^i) \frac{1}{1 + (\psi^i - 1)\epsilon^i} \widehat{mc}_t^i \right) z_t^i \right\} = 0$$

<sup>17</sup>If no intermediate goods are used in production, this becomes the Phillips curve derived by Galí *et al.* (1999).



Once again, model's restrictions do not allow us to estimate all the structural parameters. We have chosen to estimate the parameters  $\theta^i$ ,  $\omega^i$  and  $\rho^i$  (the elasticity of substitution between labour and intermediate inputs for each industry) conditional on a set of plausible values imposed on  $\beta^i$ ,  $\varepsilon^i$  and  $\psi^i$ . For  $\varepsilon^i$ , the previous calibration holds true (see Table 3). As far as the discount rate  $\beta^i$  is concerned, taking into consideration the latest results (see Table 7*bis*), we impose the condition  $\beta^i = 1$ . Finally, we calibrate the parameter  $\psi^i$  as follows:

$$\psi^i = \frac{1 + \mu^i}{\frac{W^i H^i + P^i m^i}{P^i Y^i}}.^{18}$$

Table 8 reports the main results. The general fit of the model appears extremely good: the model's overidentifying restrictions are not rejected and, with some exceptions, the coefficients appear to be of the correct sign and significantly different from zero. A more detailed examination of the latter results is now opportune.

For all industries, we obtain a large and significant fraction of backward looking price-setters, confirming that non-rational expectation behaviour is crucial in explaining inflation dynamics in Italian manufacturing industries. Moreover, it is here confirmed that estimates of  $\omega^i$  are stable: similar to the results already presented, this parameter ranges between 0.3 and 0.86.

Conversely, the estimate of parameter  $\theta^i$  decreases for all but two industries (industries 8 and 12). It follows that the derived degree of price stickiness decreases as well: the index  $D^i$  ranges between 1,25 and 2.5 quarters, while the index  $D^{iH}$  ranges between 2.8 and 8.9 quarters. These values seem extremely plausible<sup>19</sup> and confirm that price-setting behaviour is not completely homogeneous among Italian firms. Actually, asymmetries in rigidities emerge from index  $D^{iH}$ , while intersectoral differences are less statistically significant when the index  $D$  is considered.

Finally, as far as the new parameter  $\rho^i$  is concerned, we obtain significantly positive different-from-zero estimates only for industries 6, 8, 9 and 10. It follows that for industries 7 (textiles, clothing, leather and footwear), 11 (metals and metal products, other than transportation equipment), 12 (agricultural and industrial machinery) and 13 (transportation equipment) there is little possibility for meaningful substitution between labour and intermediate input.<sup>20</sup> However, a note of caution is needed regarding the interpretation of this result, since data in our possession on material costs and price are not completely reliable.

<sup>18</sup>Cf. Leith and Malley (2003).

<sup>19</sup>This consideration can be supported by recalling recent firm-level evidence, collected by a Bank of Italy survey and reported in Fabiani-Gattulli and Sabbattini (2003). This evidence indicates a frequency of 1 price change per year for the median firm. Other evidence which supports our conclusion has been produced at aggregate level by Massidda (2004); this evidence indicates a value of 2.6 quarters for  $D$  and of 4.83 quarters for  $D^H$ . Furthermore, our results also compare with the median frequency of two price changes per year reported for UK firms by Hall *et al.* (2000) and 1.4 price changes per year reported for US firms by Blinder *et al.* (1998).

<sup>20</sup>This does not deny the fact that intermediate inputs are an important part of variable cost definition.

## 4 Comments and Conclusions

This paper attempts to provide new empirical evidence on Italian manufacturing firms' pricing behaviour within a marginal cost-based *NKPC* framework. In particular we were interested in testing the extent to which points estimate of the structural parameters differ from industry to industry and are sensitive to the model specification being considered. To this end we estimate three specifications for the *NKPC*: the standard cost-based forward-looking specification; the cost-based hybrid model and, finally the Leith and Malley's *NKPC* correctly defined for multi-sectoral analysis.

Our results suggest that the hybrid *NKPC* is a plausible framework for modeling inflation dynamics within the Italian manufacturing industries. The backward-looking component of inflation is statistically robust and it does not depend on the model specification. Moreover, the fraction of firms following a rule of thumb in setting prices is almost as large as that of forward-looking price setters, sometimes being even larger.

Conversely, the average duration of price stickiness is sensitive to the definition of a firm's real marginal cost and to the model specification. Precisely, when sectoral interdependencies are ignored, we find highly volatile and upward biased estimates. We start getting reasonable coefficients, considering the hybrid model derived by Galì and Gertler with the discount rate being restricted to one and variable cost defined as labour plus material cost. These results improve even further when the *NKPC* correctly defined for multi-sectoral analysis is considered. In that case, very plausible industry-specific estimates of price inertia are obtained. Accordingly, price-setting behaviour does not appear totally homogeneous among Italian firms. Actually, asymmetries emerge when the inertia degree is measured taking non-rational behaviour ( $D^H$ ) into account, as suggested by Benigno and Lopez-Salido. Conversely, intersectoral differences are considerably reduced when the simple ratio  $D$  is considered.

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## 5 Tables

Table 1 - Branches of the Italian industrial sector

Branches
6 - Food products, beverages and tobacco
7 - Textiles, clothing, leather and footwear
8 - Timber, furniture, paper and printing, rubber and plastic products
9 - Chemical products
10 - Non-metallic mineral products
11 - Metals and metal products (other than transportation equipment)
12 - Agricultural and industrial machinery
13 - Transportation equipment

Table 2 - Non structural estimates of equation  $\pi_t^i = \beta^i E_t \{ \pi_{t+1}^i \} + \lambda^i m c_t^i$

Industries	Parameters		Tests
	$\beta^i$	$\lambda^i$	$J^i$
6	0.55 (0.088)	0.25 (0.056)	11.29 (0.335)
7	0.88 (0.003)	0.12 (0.003)	8.04 (0.529)
8	0.93 (0.05)	-.65 (0.07)	11.57 (0.315)
9	0.81 (0.005)	0.06 (0.009)	2.04 (0.98)
10	0.96 (0.022)	0.14 (0.054)	12.74 (0.238)
11	0.37 (0.098)	0.02* (0.027)	3.45 (0.486)
12	0.98 (0.014)	0.12 (0.032)	5.28 (0.872)
13	1.26 (0.036)	0.18 (0.065)	11.17 (0.344)

Table 3 - Calibration of parameters  $\mu, S, \alpha, \epsilon, \xi$

Industries	Parameters				
	$\mu$	$S$	$\alpha$	$\epsilon$	$\xi$
6	1.00	0.49	0.51	$\infty$	0
7	1.28	0.74	0.05	4.57	0.8
8	1.21	0.72	0.13	5.76	0.5
9	1.07	0.60	0.35	15.29	0.11
10	1.18	0.63	0.26	6.56	0.31
11	1.13	0.70	0.21	8.69	0.34
12	1.25	0.69	0.14	5.00	0.53
13	1.20	0.76	0.09	6	0.59

Table 4 - Structural estimates of equation  $\pi_t^i = \beta^i E_t \{ \pi_{t+1}^i \} + \left( \frac{(1-\theta^i)(1-\beta^i\theta^i)}{\theta^i} \right) \xi^i m c_t^i$

Industries		Parameters					Tests
		$\xi^i$	$\theta^i$	$\beta^i$	$\lambda^i$	$D^i$	$J^i$
6	<i>M2</i>	1	0.87 (0.05)	0.85 (0.03)	0.04	7.7	3.79 (0.96)
	<i>M3</i>	0	—	—	—	—	—
7	<i>M2</i>	1	0.7 (0.05)	1.12 (0.03)	0.09	3.3	11.9 (0.37)
	<i>M3</i>	0.8	0.84 (0.02)	1.12 (0.01)	0.01	6.25	10.9 (0.45)
8	<i>M2</i>	1	0.65 (0.07)	1.02 (0.03)	0.18	2.9	8.99 (0.53)
	<i>M3</i>	0.5	0.58 (0.08)	1.02 (0.03)	0.15	2.4	9.06 (0.53)
9	<i>M2</i>	1	0.75 (0.12)	1 (0.11)	0.08	4	10.22 (0.36)
	<i>M3</i>	0.11	0.6 (0.00)	1.08 (0.00)	0.03	2.5	2 (0.99)
10	<i>M2</i>	1	0.8 (0.1)	0.92 (0.04)	0.07	5	10.25 (0.42)
	<i>M3</i>	0.31	0.56 (0.08)	0.74 (0.00)	0.14	2.3	8.56 (0.57)
11	<i>M2</i>	1	0.7 (0.04)	0.9 (0.03)	0.16	3.33	12.15 (0.67)
	<i>M3</i>	0.34	0.56 (0.07)	0.95 (0.03)	0.13	2.3	10.3 (0.8)
12	<i>M2</i>	1	0.69 (0.06)	1.12 (0.02)	0.10	3.2	9.27 (0.51)
	<i>M3</i>	0.53	0.62 (0.08)	1.16 (0.02)	0.09	2.6	9.26 (0.51)
13	<i>M2</i>	1	0.89 (0.13)	1.02 (0.01)	0.01	9.1	14.09 (0.44)
	<i>M3</i>	0.59	0.4 (0.04)	0.93 (0.06)	0.55	1.67	14.09 (0.44)

Table 5 - Structural estimates of equation  $\pi_t^i = \gamma_b^i \pi_{t-1}^i + \gamma_f^i E_t \{ \pi_{t+1}^i \} + \lambda^i m c_t^i$

Industries	Parameters										Tests
	$\xi^i$	$\theta^i$	$\beta^i$	$\omega^i$	$\lambda^i$	$\gamma_b^i$	$\gamma_f^i$	$D^i$	$D^i H$	$J^i$	
6	<i>M4</i>	1	0.95 (0.1)	0.46 (0.04)	0.55 (0.02)	0.010	0.45	0.35	20	44.4	4.43 (0.88)
7	<i>M4</i>	1	0.9 (0.22)	0.2 (0.06)	0.81 (0.07)	0.014	0.72	0.16	10	52.6	6.86 (0.55)
	<i>M5</i>	0.8	0.87 (0.3)	0.21 (0.06)	0.8 (0.07)	0.015	0.71	0.16	7.7	38.3	8.02 (0.43)
8	<i>M4</i>	1	0.56 (0.00)	0.94 (0.00)	0.46 (0.00)	0.11	0.46	0.52	2.3	4.2	6.61 (0.76)
	<i>M5</i>	0.5									
9	<i>M4</i>	1	0.86 (0.19)	0.84 (0.22)	0.31 (0.05)	0.024	0.27	0.64	7.1	10.4	9.93 (0.27)
	<i>M5</i>	0.11	0.74* (1.4)	0.95* (1.8)	0.3 (0.04)	0.006	0.29	0.68	3.8	5.5	8.59 (0.38)
10	<i>M4</i>	1	0.75 (0.05)	0.57 (0.06)	0.56 (0.02)	0.056	0.5	0.38	4	9.1	1.7 (0.42)
	<i>M5</i>	0.31	0.45* (0.3)	0.98* (0.66)	0.55 (0.02)	0.043	0.55	0.44	1.8	4	1.4 (0.5)
11	<i>M4</i>	1	1.28 (0.44)	0.47 (0.15)	0.41 (0.05)	-0.05	0.29	0.43			3.91 (0.69)
	<i>M5</i>	0.34	0.46* (3.54)	0.34* (0.2)	0.31 (0.04)	0.16	0.31	0.46	1.8	2.7	12.37 (0.05)
12	<i>M4</i>	1	0.91 (0.2)	0.76 (0.18)	0.34 (0.06)	0.016	0.29	0.59	11.1	16.8	11.9 (0.06)
	<i>M5</i>	0.53	0.81 (0.35)	0.88 (0.39)	0.33 (0.06)	0.017	0.3	0.64	5.26	7.8	11.6 (0.07)
13	<i>M4</i>	1	0.94 (0.1)	0.56 (0.06)	0.45 (0.03)	0.013	0.45	0.44	16.7	30	14.04 (0.03)
	<i>M5</i>	0.59	0.89 (0.16)	0.59 (0.1)	0.45 (0.3)	0.014	0.38	0.45	9.1	16.5	14.4 (0.03)



Table 7 - Structural estimates of equation  $\pi_t^i = \gamma_b^i \pi_{t-1}^i + \gamma_f^i E_t \{ \pi_{t+1}^i \} + \tilde{\lambda}^i mc_t^i(tot)$

Industries	Parameters									Tests
	$\xi^i$	$\theta^i$	$\beta^i$	$\omega^i$	$\lambda^i$	$\gamma_b^i$	$\gamma_f^i$	$D^i$	$D^{iH}$	$J^i$
6	1	0.99 (0.12)	0.51 (0.07)	0.49 (0.02)	0.002	0.39	0.41	100	19.6	5.36 (0.80)
7	1	0.99 (0.02)	0.5 (0.02)	0.52 (0.02)	0.002	0.42	0.4	100	208	5.07 (0.75)
	0.8	0.86 (0.02)	0.65 (0.03)	0.42 (0.02)	0.025	0.36	0.48	7.14	12.3	4.25 (0.83)
8	1	0.56 (0.00)	0.94 (0.00)	0.46 (0.00)	0.11	0.46	0.52	2.3	4.2	9.71 (0.37)
	0.5	0.39* (0.22)	1.2* (0.7)	0.45 (0.04)	0.10	0.51	0.53	1.64*	3	10.23 (0.33)
9	1	0.94 (0.15)	0.78 (0.13)	0.3 (0.05)	0.01	0.26	0.62	16.7	23.8	10.2 (0.33)
	0.11	0.76* (1.0)	0.92* (1.2)	0.3 (0.05)	0.005	0.29	0.67	4.2	5.95	8.6 (0.38)
10	1	0.97 (0.01)	0.46 (0.01)	0.56 (0.01)	0.006	0.45	0.36	33.3	75.76	3.63 (0.3)
	0.31	0.93 (0.17)	0.5 (0.08)	0.46 (0.03)	0.005	0.39	0.4	14.3	26.45	5.7 (0.45)
11	1	0.94 (0.08)	0.5 (0.07)	0.51 (0.05)	0.013	0.42	0.39	16.7	34	6.02 (0.42)
	0.34	0.84 (0.22)	0.57 (0.18)	0.51 (0.05)	0.012	0.44	0.41	6.25	12.76	6.03 (0.42)
12	1	0.76 (0.25)	0.58 (0.2)	0.54 (0.04)	0.06	0.48	0.39	4.17	9.1	10.68 (0.06)
	0.53	2.66 (1.27)	0.24 (0.11)	0.41 (0.045)	-0.08	0.18	0.29			7.11 (0.625)
13	1	0.83 (0.15)	0.6 (0.09)	0.47 (0.03)	0.04	0.41	0.44	5.88	11.1	14.4 (0.025)
	0.59	0.73 (0.23)	0.69 (0.19)	0.47 (0.03)	0.04	0.43	0.46	3.7	7	14.4 (0.025)

Table 7bis - Structural estimates of equation  $\pi_t^i = \gamma_b^i \pi_{t-1}^i + \gamma_f^i E_t \{ \pi_{t+1}^i \} + \tilde{\lambda}^i mc_t^i(tot)$

Industries	Parameters						Tests
	$\xi^i$	$\theta^i$	$\beta$	$\omega^i$	$D^i$	$D^{iH}$	$J^i$
6	1	0.7 (0.02)	1	0.36 (0.01)	3.3	5.2	3.66 (0.93)
7	1	0.75 (0.02)	1	0.25 (0.02)	4	5.3	6.86 (0.74)
	0.8	0.74 (0.02)	1	0.26 (0.02)	3.8	5.2	6.54 (0.77)
8	1	0.48 (0.02)	1	0.46 (0.03)	1.9	3.6	9.98 (0.44)
	0.5	0.46 (0.04)	1	0.46 (0.03)	1.8	3.4	9.85 (0.36)
9	1	0.86 (0.05)	1	0.21 (0.05)	7.14	9.04	10.5 (0.4)
	0.11	0.81 (0.05)	1	0.23 (0.05)	5.3	6.8	9.88 (0.45)
10	1	0.77 (0.03)	1	0.31 (0.03)	4.3	6.3	12.5 (0.25)
	0.31	0.62 (0.04)	1	0.37 (0.03)	2.6	4.2	10.67 (0.38)
11	1	0.71 (0.03)	1	0.28 (0.03)	3.5	4.8	10.14 (0.43)
	0.34	0.56 (0.02)	1	0.43 (0.02)	2.3	4	9.6 (0.48)
12	1	0.77 (0.06)	1	0.27 (0.05)	4.3	6	13.18 (0.21)
	0.53	0.75 (0.06)	1	0.29 (0.05)	4	5.6	12.9 (0.23)
13	1	0.59 (0.03)	1	0.45 (0.03)	2.4	4.4	14.1 (0.17)
	0.59	0.52 (0.03)	1	0.5 (0.03)	2.1	4.2	14.16 (0.17)

Table 8 - Structural estimates of Eq. (8)

Industries		Parameters								Tests
		$\theta^i$	$\beta$	$\omega^i$	$\rho^i$	$\gamma_b^i$	$\gamma_f^i$	$D^i$	$D^{iH}$	$J^i$
6	<i>M6</i>	0.37 (0.05)	1	0.49 (0.02)	14.9 (2.01)	0.57	0.42	1.59	3.2	4.67 (0.86)
7	<i>M6</i>	0.2 (0.06)	1	0.86 (0.06)	-13.8* (11.6)	0.8	0.19	1.25	8.9	7.74 (0.56)
8	<i>M6</i>	0.59 (0.04)	1	0.31 (0.03)	17.4 (4.4)	0.34	0.66	2.44	3.5	8.44 (0.49)
9	<i>M6</i>	0.6 (0.09)	1	0.3 (0.05)	16.6 (2.6)	0.33	0.67	2.5	3.6	4.3 0.8
10	<i>M6</i>	0.32 (0.05)	1	0.48 (0.05)	9.5 (1.31)	0.6	0.4	1.48	2.8	4.75 (0.85)
11	<i>M6</i>	0.43 (0.04)	1	0.6 (0.04)	-1.05* (3.36)	0.58	0.42	1.75	4.4	4.34 (0.89)
12	<i>M6</i>	0.75 (0.07)	1	0.31 (0.06)	-4.8* (7.88)	0.29	0.71	4	5.8	10.16 (0.34)
13	<i>M6</i>	0.5 (0.03)	1	0.49 (0.03)	1.5* (2.87)	0.5	0.5	2	3.9	8.84 (0.47)

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