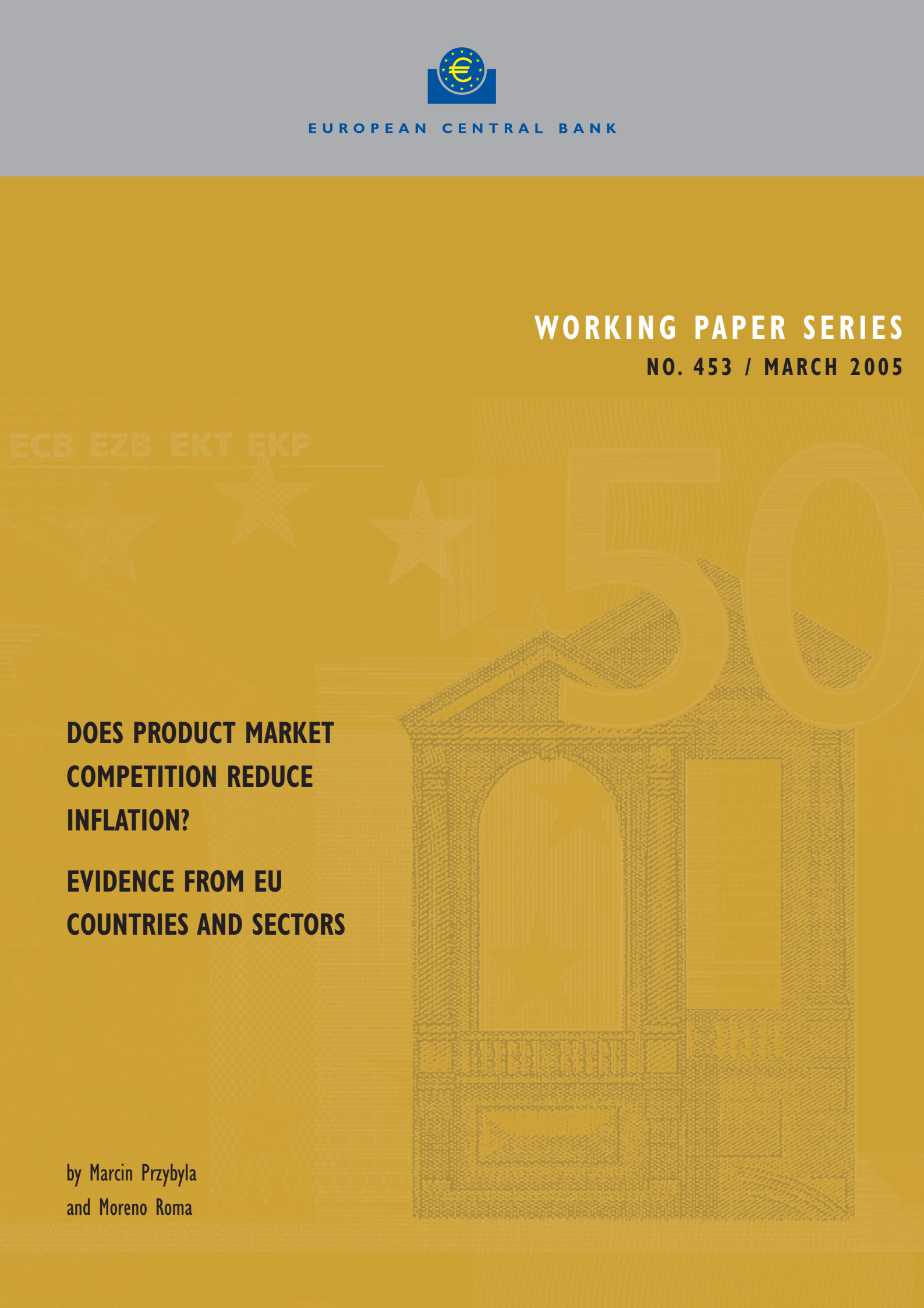

EUROPEAN CENTRAL BANK

WORKING PAPER SERIES

NO. 453 / MARCH 2005

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EVIDENCE FROM EU COUNTRIES AND SECTORS

by Marcin Przybyla
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CONTENTS

Abstract

In this paper we explore the link between the intensity of product market competition and inflation rates across EU countries and sectors. We consider long-term averages of inflation rates in order to remove the cyclical behavior of inflation over time and as alternative proxies of competition we use the level of mark-up, profit margin, the profit rate and a survey based "intensity of competition" variable.

Results for both aggregate and sectoral panels show that the extent of product market competition, as proxied by the level of mark-up in particular, is an important driver of inflation. Notwithstanding some caveats associated with the measurement of the proxies of competition used, our findings suggest that higher product market competition reduces average inflation rates for a prolonged period of time. Moreover, results both at the aggregate and sectoral level are generally confirmed by a wide set of robustness tests.

Keywords: Inflation, Competition, Estimation and Panel Data Analysis.

JEL Classification: C21, C23, E31

Non-technical summary

The role of product market reforms in achieving the objective of higher and sustainable non-inflationary growth has recently received a lot of attention amongst policy makers and academics. The economic literature has explored quite extensively the link between product market competition and the price level, concluding that higher competition leads to a lower price level. The investigation of the relationship between product market competition and inflation is however less prominent (Neiss (2001) and Cavelaars (2003)) and represents the focus of this work.

In this paper, we examine the link between product market competition and price formation, which persists for a prolonged period of time, i.e. which goes beyond temporary effects. To this end, in order to remove the cyclical behavior of inflation, we consider long-term averages of inflation rates for a panel of EU countries and sectors. Given that product market competition cannot be measured directly, we use as alternative proxies the level of mark-up, profit margin, the profit rate and a survey based "intensity of competition" variable.

Our paper contributes to the literature in several ways. First, compared to the existing literature, the paper focuses on a longer time-horizon (1980-2001) and on a panel of EU countries. Second, alternative proxies of product market competition are used and critically assessed in order to evaluate which proxy performs better. Third, the analysis is extended to a sectoral level and this empirical investigation has received limited attention in the literature especially as far as the study of EU countries is concerned. This extension entails the use of panel data analysis.

Results for both the aggregate and sectoral panels indicate that competition in product markets plays an important role in explaining average inflation rates across countries and sectors. In particular, our findings suggest that higher product market competition reduces average inflation rates for a prolonged period of time, thus empirically confirming the economic rationale of our investigation. The negative relationship between competition and average inflation continues to hold when controlling for country size, monetary policy, country openness and the level of country development. Moreover, results both at the aggregate and sectoral level are generally confirmed by a wide set of robustness tests. This entails both testing for alternative proxies of product market competition and for different specification of the estimation models.

Notwithstanding the empirical difficulties in measuring product market competition and the fact that some methodological caveats and some data limitation may play a role, we can conclude that amongst the proxies used mark-up, measured as the inverse of the labour

income share, performs best in explaining average inflation rates both at an aggregate and a sectoral level.

The policy implications of this paper are twofold. First, the empirical evidence that higher product market competition leads to lower average inflation rates appears to be robust and confirms previous findings. Second, the claim of policy makers and central banks to urge progress in product market reforms is supported by the fact that this is likely to lead to a permanently lower level of inflation. However, it is worth stressing that conclusions should be assessed with caution given that in the period considered, 1980-2001, some other factors affecting inflation and going beyond the effect of product market competition might have also played a role. Moreover, average inflation rates in the sample period examined were significantly higher than in the euro area or in the EU now and this is likely to imply that the policy conclusions drawn may be less stringent in a "low inflation environment".

1. Introduction

There is a high degree of interest among policy makers and academics regarding the role played by structural reforms to achieve the objective of higher and sustainable non-inflationary growth. Product market reforms are likely to promote a more competitive economic environment. If higher product market competition reduces inflation, and therefore contributes to a more stable macroeconomic environment, this is likely to be beneficial for growth and would support the policy call of speeding-up structural reforms to meet the objectives set-up within the Lisbon agenda.

The economic literature has explored quite extensively the link between product market competition and the price level, concluding that higher competition leads to a lower price level (see for example Armstrong and Vickers (1993), ECB (2001), ECB (2002), Economist Intelligence Unit (2001), European Commission (2001)). The intuition for this result is that higher competition stimulates a more efficient use and allocation of resources thereby triggering price reductions and a temporary downward pressure on the inflation rate. The degree of product market competition is also likely to affect firms' pricing behaviour and the extent of inflation persistence[2]. Fabiani, Gattulli and Sabbatini (2004) find that, in the case of a demand shock, Italian firms tend to change prices less promptly in a non-competitive environment. This finding is in line with theoretical predictions suggesting that the higher the degree of competition the more a firm's pricing strategy is likely to be affected by the behaviour of its competitors (see also Martin (1993)). The investigation of the relationship between product market competition and inflation is however less prominent in the literature (Neiss (2001) and Cavelaars (2003)) and represents the focus of this paper. Concentrating on inflation rates rather than on the price levels, we are interested in finding possible links between product market competition and price formation which persist for a prolonged period of time, i.e. which go beyond temporary effects.

In this paper, we explore the link between the intensity of product market competition and inflation rates across countries and sectors. To this end, in order to remove the cyclical behavior of inflation, we consider long-term averages of inflation rates for a panel of EU countries and sectors[3]. Given that product market competition cannot be measured directly,

[2] Several papers dealing with inflation persistence and presenting research within the Eurosystem Inflation Persistence Network can be found under http://www.ecb.int/pub/html/index.en.html.

[3] A possible interesting extension of this paper could be to use yearly inflation rates rather then long-term averages and insert a measure of output gap among the explanatory variables in order to take into account cyclical variations in inflation rates. Adding a temporal dimension would also allow the possibility of taking into account the role of inflation expectations within a New Keynesian Phillips

we use as alternative proxies the level of mark-up, profit margin, the profit rate and a survey based "intensity of competition" variable.

Our paper contributes to the literature in several ways. First, compared to the existing literature, the paper focuses on a longer time-horizon (1980-2001) and on a panel of EU countries. Second, alternative proxies of product market competition are used in order to assess which proxy performs better. Third, the analysis is extended to a sectoral level, this empirical investigation has received less attention in the literature especially as far as the study of EU countries is concerned[4]. This extension entails the use of panel data analysis.

The remainder of the paper is organized as follows: section 2 focuses on the methodology presenting the economic rationale of the investigation, the different proxies of product market competition used and the estimation models. Section 3 describes the aggregate and sectoral data used. Empirical results for the aggregate and sectoral samples together with robustness tests are presented in section 4 and 5 respectively. Section 6 concludes.

2. The Methodology

In this section we focus on the methodology used. In section 2.1 we discuss the economic rationale of our investigation, in section 2.2 we present the different proxies of competition used in the empirical analysis and in section 2.3 we describe the econometric methodology used.

2.1. Macroeconomic rationale

The rationale to claim that the inflation rate is affected by the intensity of product market competition is twofold. First, in an economy characterised by product market imperfections and rigidities, the central bank could have an incentive to set actual inflation above expected inflation as a means to raise output growth. This well-known argument has been originally put forward by Kydland and Prescott (1977) and Barro and Gordon (1983) and is known in the literature as the dynamic inconsistency theory. The argument can be formalised as follows:

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curve framework. These extensions go however beyond the scope of the paper of investigating the effects of product market competition on inflation rates.

[4] Symeonidis (2001) analysed the impact of price competition on endogenous innovative output, market structure and profitability in R&D-intensive manufacturing industries in the UK. He found that an intensification of price competition, determined by an exogenous institutional change, had no significant effect on innovation output while it caused a rise in concentration in the industries examined. Leith and Malley (2003) developed a sectoral model of firms' pricing behaviour for US manufacturing industries and found that firms with more market-power, as measured by a higher mark-up, adjust prices less frequently than firms in more competitive industries. Sauner-Leroy (2003) used company level data for a panel of EU countries and showed that falls in price costs margins between 1989 and 1993 were consistent with increased competition following the implementation of the single market.

$$L = \frac{1}{2}[\pi^2 + \lambda(y - \theta y^*)^2] \quad [1]$$

Where L indicates a loss function, π the inflation rate, y and y^* actual and potential output growth respectively, $\lambda > 0$ the central bank's weight attached to output growth and $\theta > 1$ is a measure of the degree of distortions in the economy[5]. The objective function considered is based upon the assumption, widely used in the literature, that monetary authorities dislike departure of actual output and inflation from their respective target values[6].

The existence of distortions could be due to the presence of imperfect competition as proposed by Lane (1997) and Neiss (2001) or other forms of product market rigidities such as state control, strict product market regulation or distortionary taxation as in Beetsma and Bovenberg (1999). Notwithstanding the focus of the paper on product markets, the parameter θ could also capture labour market rigidities such as the wedge between the monopoly level of employment and the competitive level or the degree of employment protection legislation. Minimising the loss function [1] and setting actual output equal to potential output in equilibrium, we get

$$\pi = \lambda y^* (\theta - 1) \quad [2]$$

implying that $d\pi / d\theta > 0$, i.e. the higher the distortion in the market, the higher the inflation rate.

Empirical evidence supports the idea that increased product market competition is beneficial to consumers in term of lower prices in selected network industries (ECB (2001)). As a matter of example, increased competition in the telecommunications sector has clearly exerted a downward influence on price developments in recent years for a prolonged period of time (ECB (2003)). Other studies such as Neiss (2001) and Cavelaars (2003) suggest that product market imperfections play a role in explaining cross-country inflation rates and have a permanent impact on average inflation rates.

A second and somewhat related argument can be put forward to claim that more competitive economies are likely to experience lower inflation rates in the long run. The more competitive an economy, the more flexible it should be in terms of prices and factor substitution of inputs. In particular, more flexible prices are likely to render the monetary commitment to low inflation more credible (see Rogoff 2003). Moreover, a competitive economy should be able to adjust more quickly to unanticipated shocks. If an economy is hit by a negative supply side shock such as an oil price shock, the output loss and the increase in inflation and wages

[5] The preferred inflation rate π^* has been normalised to zero.
[6] The loss function described is standard in monetary economic literature and is not meant to represent the behaviour of the ECB, which focuses on price stability over the medium term.

following the shock are likely to be less severe in a more competitive economy (Rotemberg and Woodford (1996)).

2.2. Proxies for competition

Perfect competition is generally associated with a market structure where individual economic agents have no market power and are price takers. In a competitive setting firms produce homogenous products, are able to enter and exit the market freely and face a perfectly horizontal demand curve. Competition is generally believed to drive market prices down to the competitive level equal to the marginal costs. Such a competitive equilibrium is *Pareto optimal*, i.e. it cannot be replaced by another one that would increase the welfare of some consumers without harming others.

A market can be characterised by *de facto* or *de jure* competition. *De facto* competition is a case where effective competition exists in the market as described above, whilst *de jure* competition is a situation where competition is "formally" possible given the existing regulatory framework, but a limited number of large players still retain a dominant position. Additionally, competition can be based on prices (or quantities) but also on *non-price factors*. Non-price competition is common in cases of price regulation. Examples of non-price competition include improving the quality of products, providing and extending warranty, advertising a product and changing its characteristic.

In practise, measuring product market competition is a complex task. Given that product market competition cannot be measured directly, we need to use proxies. We use mark-up as a first proxy of product market competition[7]. The mark-up is intended to proxy the ratio of price over marginal costs in the calculation of the so-called Lerner index, the ratio of price minus marginal costs over price, which measures the intensity of competition within a market[8]. Given that the direct empirical measurement of the Lerner index is quite difficult because marginal costs of firms are not observable, we measure mark-up as the inverse of the labour income share in the economy, following Gali (1995), Neiss (2001) and Cavelaars (2003).

Using this methodology is equivalent to assuming that the elasticity of output with respect to labour input is equal across countries and, more specifically, using a Cobb-Douglas production function $Y = AL^{\alpha}K^{1-\alpha}$ this implies that the parameter α is equal across countries. In other words differences in technologies across countries are not expected to

[7] Mark-up may not fully reflect the degree of product market competition when trade unions are able to appropriate large quasi-rents. When an incumbent tries to deter new entrants by cutting prices, mark-up could also underestimate the monopoly power of a firm.
[8] Indicating the mark up with m = P/MC and the Lerner Index with B = (P-MC)/P we get B = 1 – 1/m.

systematically affect their average rates of inflation. This assumption seems reasonable given the relatively homogenous set of countries examined[9]. Furthermore, and most importantly, this methodology does not explicitly take into account capital stock[10]. To this end we have tried as alternative proxies of product market competition other indicators that take also into account capital stock (see below, for a discussion see also European Commission (2004)).

As a second proxy for product market competition, we compute profit margin as the ratio of operating surplus to output. In computing profit margin we face several methodological issues (for an exhaustive discussion see ECB (2004)). First of all, in the national account framework, operating surplus includes mixed income (imputed labour income of self-employed). We consider two different measures of profit margin: the first one, unadjusted, which includes the income of self-employed, and the second one, adjusted profit margin, which excludes the imputed labour income of the self-employed, under the assumption that the labour income of a self-employed person equals compensation of an employee. Additionally, operating surplus can be defined on a gross or net basis (i.e. excluding the consumption of fixed capital). Finally, some additional methodological problems emerge in defining the measure of output to which gross operating surplus is related. Output can be defined either in terms of production or in terms of value added[11]. Given that the ratio of intermediate inputs (the difference between production and value added) to total output differs across sectors and affects the measurement of profit margin, we compute profit margin using value added in the denominator. All in all, there are several alternative ways of defining profit margin and there is no superior definition fitting all purposes. In order to decide which measure to use in the empirical analysis we compute several correlations between competing definitions of profit margin indicators and other proxies of competition and choose the one with the highest correlation (see Annex Tables 1 to 4). Table 1 below presents the set of indicators that we have selected on the basis of this analysis, namely net unadjusted operating surplus over GDP for the aggregate sample and gross unadjusted operating surplus over value added for the sectoral sample.

[9] See Cavelaars (2003) for a more detailed discussion.
[10] The mark-up m is however indirectly related to the capital share (KS) given that KS = 1 – Labour Income Share.
[11] This holds at the sectoral level, whilst at the aggregate level we use GDP.

Table 1: Summary of the proxies of competition used in the empirical analysis.

Proxies of competition:	Aggregate Sample	Sectoral Sample
Mark-up	GDP / Compensation of employees	Value added / Compensation of employees
		Estimated sectoral mark-up using Roeger (1995) methodology
Profit Margin	Net unadjusted Operating Surplus/GDP	Gross unadjusted Operating Surplus / Value Added
Profit Rate	Net unadjusted Operating Surplus/Capital Stock	-
Intensity of Competition	Survey variable (WEF)	Survey variable (WEF)
Openness	Import / GDP	-
Indicators of product market regulation	Nicoletti et al. (2000)	Nicoletti et al. (2000)

The proxies of competition considered so far do not take into account one important factor of production, namely capital stock. To this end, we use as additional measure of profitability the rate of return on invested capital or rate of profit defined as:

$$r = OperatingSurplus / P_k K$$

where K is the real capital stock and P_k is the deflator of the capital stock. Following the discussion above we use the net unadjusted operating surplus as numerator in the calculation of the rate of profit for the aggregate sample[12].

Furthermore, acknowledging the simplicity and the possible limitations associated with the mark-up measure computed as described above, we econometrically estimate mark-up at the sectoral level following the methodology proposed originally by Roger (1995) and presented in Martins et al (1996). This methodology allows estimating the Lerner index B = (P-MC)/P using the following equation:

$$\Delta y_t = B\Delta x_t + \varepsilon_t \qquad [3]$$

where

$$\Delta y = (\Delta q + \Delta p) - \alpha(\Delta l + \Delta w) - \beta(\Delta n + \Delta p^n) - (1 - \alpha - \beta)(\Delta k + \Delta r)$$
$$\Delta x = (\Delta q + \Delta p) - (\Delta k + \Delta r)$$

and q and p are logarithm of gross output and its respective price, α is the labour share in total output, l and w are the logarithm of total employment and the wage rate respectively, β is the share of intermediate output in total output, n and p^n are the logarithm of intermediate inputs and their prices and K and r are the logarithm of capital and its rental price[13].

[12] For a discussion of the link between mark-up and the rate of profit in some euro area countries see Pierluigi (2003).

[13] To calculate the rental price of capital we follow a simplified version of the methodology proposed by Hall and Jorgenson (1967): $R = ((i - \pi^{\exp}) + \delta) p_k$, where i is long-term nominal interest rate, π^{exp} is

The dependent variable Δy in equation [3] can be interpreted as a nominal Solow residual and the explanatory variable Δx_t is the growth rate of the nominal output / capital ratio.

It is worth stressing that equation [3] provides an unbiased estimate of the Lerner index B only in the presence of constant returns to scale. The presence of increasing returns to scale induces a downward-bias in the estimation of the mark-up[14]. Moreover, the presence of sunk-costs is also likely to bias downward the Lerner index given that the fraction of the capital stock which is sunk has to be subtracted from capital leading to lower marginal cost and higher mark-ups. These limitations together with those related to data availability discussed later have to be borne in mind when interpreting the results presented in Section 3.2.

As an alternative measure of product market competition we also use the index "Intensity of local competition" published by the World Economic Forum (2002) (WEF) in The Global Competitiveness Report 2001-2002. This index is based on survey data across countries and is computed as arithmetic mean of responses from 90 senior executives whose companies are part of the World Economic Forum. The questions are meant to assess the degree of product market competition in local markets.

We also include in our models indicators of product market regulation, based on Nicoletti, Scarpetta and Boylaud (2000). In particular, we use an indicator of overall economic regulation, regulation of competition, barrier to competition and intensity of state control. These indicators could also be useful proxies to capture the degree of product market flexibility and the degree of competition in the economy as shown in Hayri and Dutz (1999).

Finally, we also consider in the models a proxy for market openness (export plus import over GDP) for two reasons. First, we are also interested in assessing the link between openness and inflation as done in Lane (1997), even if this is not the main objective of the paper. Second, the degree of market openness could be considered as an additional proxy of product market competition.

Having used a relatively broad set of indicators to proxy the intensity of product market competition, a natural question emerges - which will be addressed in the empirical investigation - which of these indicators appears to perform better in explaining long-term inflation rates within the panel of countries examined?

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the expected inflation rate estimated using a HP filter of the GDP deflator and δ is the rate of depreciation set to 5% across all sectors.

[14] See Martins et al (1996) for a discussion.

2.3. The Models

In order to explore empirically the link between the intensity of competition and inflation rates at the sectoral level we use cross-country/cross-industry data. Some of the explanatory variables used are country specific and therefore take the same value within a sector. Moulton (1986) shows that the use of OLS to estimate models with variables taking the same value on a cluster of observations can produce biased and inconsistent estimates of coefficients and standard errors. In order to overcome this problem we apply the approach suggested in Nicoletti et. al. (2001) and we estimate the following model in vector form:

$$\pi = \alpha i_{NS} + X\beta + u = Z\delta + u \quad [4]$$

$$u = Z_{\mu}\mu + v \quad [5]$$

where π is a NS x 1 matrix of inflation rates in country i=1,2…,N and sector s=1,2…,S, X is a NS x K matrix of explanatory variables in levels[15], i_{NS} is a vector of ones with dimension NS, $Z = [i_{NS}, X]$, $\delta' = (\alpha', \beta')$ represents the vector of coefficients we want to estimate and the error term u is specified as in equation [5] where, $Z_{\mu} = I_N \otimes i_S$, $\mu' = (\mu_1, ..., \mu_N)$ and $v' = (v_{11}, ..v_{1T} ..., v_{NS})$.

The matrix X of explanatory variables contains both the proxy of competition used and other variables that we include in the regression in order to control for other factors that may influence long-term inflation rates such as market regulation, country size, monetary policy, openness and GDP per capita. Some of the explanatory variables used are not sector specific, therefore they take the same value for each sector within a country (see section 3 for a detailed description). The notation used above is however encompassing a more general case in which each explanatory variable is both sector and country specific.

Z_{μ} is a matrix of individual country dummies included in the regression in the case of fixed effects estimation or a selector matrix of one and zeros in the case of random effects estimator. More specifically, if the conditional distribution of μ_i's given X can be viewed as identical across i, then fixed effects estimation should be performed and this implies substituting [5] into [4] and estimating directly the resulting equation using a least-squares-dummy-variables (LSDV) approach. If the μ_i's can be seen as randomly drawn from a

[15] Most of the explanatory variables used are computed as ratios over GDP or value added. We have taken averages of the levels of the explanatory variables rather than averages of growth rates, given that we are analysing long-term averages of inflation rates and we are not interested in cyclical variations which are likely to be better captured by growth rates of the explanatory variables.

common population, then random effects estimation is applied. In the case of random effects estimation the following holds:

$$\mu_i \approx IID(0, \sigma_\mu^2)....and...v_{is} \approx IID(0, \sigma_v^2)$$

where $\mu_i's$ and $v_{is}'s$ are independent, X_{is} are independent of the $\mu_i's$ and $v_{is}'s$ for each i and s.

Additionally, the random effect specification implies a homoskedastic variance and a covariance matrix exhibiting serial correlation over time only between the disturbances of the same individuals:

$Cov(u_{is}, u_{jp}) = \sigma_\mu^2 + \sigma_v^2$ for i = j and s = p and $Cov(u_{is}, u_{jp}) = \sigma_\mu^2$ for i = j and s $\neq$ p.

To test the random-effect specification against the simple linear model we apply a Lagrange Multiplier test developed by Breusch and Pagan (1980) and we perform the Hausman (1978) test to check whether the random effect model is correctly specified, i.e. if the $\mu_i's$ are uncorrelated with the $X_i's$.

3. The data

3.1. Aggregate Data

For the estimations at the aggregate level we use annual data for the 15 EU countries and, for each variable considered, we take the 1980-1990 and 1991-2002 averages. As done in Neiss (2001) and Cavelaars (2003), we compute long-term averages because we are not concerned with explaining short-term cyclical fluctuations in inflation rates. The aim of the paper is indeed to investigate the link between inflation rates and product market competition and the latter is considered a structural feature of an economy which goes beyond short-run developments. Another possible approach which could represent an interesting extension of this paper would be to use yearly inflation rates rather then long-term averages and insert a measure of output gap among the explanatory variables in order to take into account cyclical variations in inflation rates.

For each country the inflation rate is computed as the annual change of the logarithm of the GDP deflator. We use alternative proxies of product market competition (see also section 2.2). First, we compute the mark-up calculated as the inverse of the labour income share. Second, we calculate profit margin as the ratio of net unadjusted operating surplus to GDP. Third, we use a measure of the "intensity of competition" as reported in the Global

Competitiveness Report 2001-2002. Finally we use the rate of profit computed as the ratio of net unadjusted operating surplus to the capital stock.

Since we are also interested in the relationship between inflation and the openness of the economy, we include a measure of import penetration computed as a ratio of the level of nominal imports plus exports to nominal GDP. To control for country size we use the logarithm of nominal GDP. The logarithm of nominal GDP per capita is used as a proxy of the inflation aversion of each country and as an indicator of the level of its development (as in Romer (1993)). Developments in monetary policy, measured as the growth rate of M3, are also taken into consideration. As suggested by Romer (1993), to reduce the effect of possible outliers in the sample we use logarithms of GDP and GDP per capita in our regressions.

Table 2: Sample statistics, aggregate data 1980-2001

Variable	Number of observations	Mean	Standard deviation	Min	Max
Inflation	15	5.24	2.99	2.39	12.79
Mark-up	15	2.00	0.32	1.76	3.02
Profit margin	15	23.91	8.48	15.52	48.00
Rate of profit	14	7.83	2.35	4.38	12.95
Openness	15	81.82	48.37	43.58	217.74
Log(GDP per capita)	15	2.63	0.40	1.74	3.16
Log(GDP)	15	5.14	1.35	2.23	7.18
Intensity of competition	13	5.80	0.40	5.20	6.30

Source: European Commission AMECO database, except "Intensity of competition" from World Economic Forum (2002), own calculations.

Some summary statistics of inflation and the explanatory variables are reported in Table 2. The average inflation rate for the sample is 5.2%, however it differs significantly across countries ranging from 2.4% in Germany to 12.8% in Greece. The average value of the mark-up is 2, meaning that labour earns, on average, 50% of GDP and that labour and profit share should be broadly equal. A mark-up of 2 implies that prices are on average twice marginal costs and that producing an additional unit of output would yield a 50% "margin" as approximated by the Lerner Index. Notwithstanding the difference in the sample and country coverage, this result is broadly in line with Neiss (2001) and Cavelaars (2003). The EU countries are not a homogenous group with respect to mark-up, with the lowest average value

of 1.8 in Sweden and the highest close to 3 in Greece. The average profit margin in the sample is 24% and the average rate of profit is close to 8%.

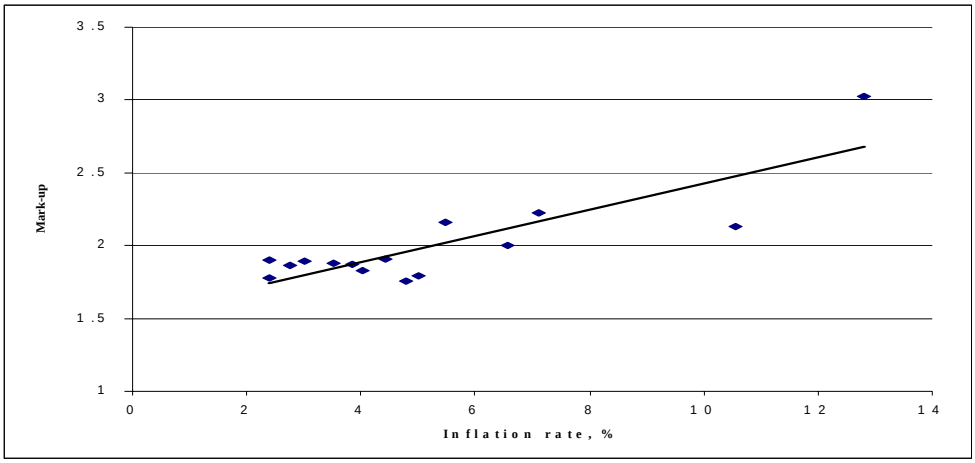
In Table 3 we present a simple correlation matrix between inflation and the explanatory variables. Inflation and mark-up have a strong positive correlation, implying that higher values of inflation rates are associated with higher mark-ups. Figure 1 shows a scatter plot of the mean inflation rate against the mark-up for each country. A visual assessment seems to confirm our thesis that higher mark-ups are associated with higher average inflation rates. In addition, we find that the inflation rate is negatively correlated with openness, which is consistent with Romer (1993) predicting lower inflation rates in more open economies. Furthermore, countries with a higher level of development measured by the logarithm of GDP per capita tend to have lower inflation. We also find a negative correlation between the size of a country, measured by the logarithm of GDP, and the mark-up. Cavelaars (2003) explains this relationship by the fact that when the number of suppliers is relatively large, such as in a large economy, a collusive behaviour among firms is less likely to occur. Finally, we find a strong negative correlation between the logarithm of GDP per capita and mark-up. This would suggests that countries where firms have higher mark-up, indicating a higher monopoly power, would tend to have lower per capita GDP, which reflects the intuition that greater competition should be supportive for higher output growth (as discussed for example in Hayri and Dutz (1999) and Bayoumi, Laxton and Pesenti (2004)). The positive correlation between inflation and the profit rate appears to be relatively weak.

Table 3: Correlation matrix, aggregate data

	Inflation	Mark-up	log(GDP per c.)	Openness	Log(GDP)	Profit rate
Inflation	1					
Mark-up	0.85	1				
Log(GDP per capita)	-0.85	-0.69	1			
Openness	-0.35	-0.18	0.39	1		
Log(GDP)	-0.2	-0.23	0.02	-0.71	1	
Profit rate	0.23	0.63	-0.16	0.39	-0.26	1

Source: European Commission AMECO database and own calculations

Figure 1: Average inflation rate vs. average mark-up, EU countries, 1980-2001



Source: European Commission AMECO database and own calculation.

3.2. Sectoral Data

In section 5 we focus on a sectoral analysis. Due to limited availability of some of the variables of interest, we limit our sample to 8 EU countries (Austria, Germany, Denmark, Finland, France, Italy, Portugal and Sweden). In terms of time coverage, we analyse the same sample period as for the aggregate data and we compute long-term averages over the 1980-2001 period. In our analysis we focus on non-agriculture business sectors only, given that the agricultural sector is likely to be affected by distortionary policies at the EC level such as subsidies, price controls and the like. Additionally, due to differences in classification across countries, we had to exclude mining and quarrying from the sample. In Annex 8.1.2 we provide a detailed list of the sectors used (which cover both manufacturing and non-manufacturing sectors), while in Annex Tables 5 and 6 we present summary statistics and correlation matrix between inflation and the other explanatory variables.

As a measure of inflation at a sectoral level we use the difference of the logarithm of value added deflator. We calculate mark-up as the inverse of labour income share and for an alternative measure of the degree of market competition we compute profit margin as gross unadjusted operating surplus over value added. In the calculation of both mark-up and profit margin at the sectoral level we use value added data at basic prices, which include taxes levied on production (namely current taxes on the labour and capital employed, such as payroll taxes, and taxes on vehicles and buildings). The inclusion of these taxes introduces an upward bias in the mark-up calculations and a downward bias in profit margin. However, as neither value added at factor price nor detailed information on tax rates by sector and by country are available we could not correct for these effects.

We also used the methodology suggested by Roger (1995) outlined in section 2.2 to econometrically estimate mark-ups. Due to data limitation, particularly on the capital stock side, we estimated equation [3] for 5 countries and for 14 sectors covering the period 1980-2001 (see Annex 8.1.3). Mark-ups are calculated as 1/(1-B), where B is the estimated Lerner-index coefficient from equation [3]. Results are presented in Table 4. Although we use a shorter time frame and a different sectoral breakdown and coverage, our results are broadly in line with those reported in Martins et al (1996). The estimated mark-up shown in Table 4 is generally lower than the average sectoral mark-up computed as the inverse of the labour income share yielding an average mark-up of 1.82 (corresponding to a sectoral Lerner index of 45%). A comparison of the two indicators is however complicated by the different methodology and the different country and sectoral coverage used in the calculation.

Additionally, we find that the estimated mark-up is positively correlated with the simple measure of mark-up defined as the inverse of the labour income share. We generally find a correlation coefficient between 0.4 and 0.5 for most of the countries examined.

Finally, we use a set of indicators (Nicoletti, Scarpetta and Boylaud (2000)) to control for the degree of product market institutions in each country. The indicators used for this aim are the degree of overall economic regulation, regulation of competition, barrier to competition and state control. (See Appendix 8.1.1 for more detailed data description, definitions and sources.)

Table 4 Estimated sectoral mark-ups

Germany

ISIC code	Sector	B	Std. error	p-value	Mark-up
1516	Food Products, bevarages and tabaco	0.12	0.03	0.00	1.13
1719	Textiles, textile products, leather and footwear	0.17	0.04	0.00	1.20
2000	Wood and products of wood and cork	0.16	0.05	0.02	1.19
2122	Pulp, paper, paper products, printing and publishing	0.25	0.10	0.03	1.34
2325	Chemical, rubber, plastic and fuel products	0.18	0.07	0.04	1.22
2600	Other non-metalic mineral products	0.23	0.06	0.00	1.30
2728	Basic metals and fabricated metal products	0.12	0.04	0.03	1.13
2933	Machinery and equipment	0.09	0.06	0.20	1.10
3435	Transport equipment	0.12	0.08	0.17	1.13
3637	Manufactutring n.e.c.	0.17	0.03	0.00	1.21
6063	Transport and storage	0.08	0.09	0.41	1.08
6400	Post and telecommunication	0.37	0.08	0.00	1.58
6567	Financial intermediation	0.38	0.12	0.01	1.61
7074	Real estate, renting and business activities	0.55	0.03	0.00	2.22

Denmark

ISIC code	Sector	B	Std. error	p-value	Mark-up
1516	Food Products, bevarages and tabaco	0.03	0.06	0.66	1.03
1719	Textiles, textile products, leather and footwear	0.10	0.03	0.02	1.11
2000	Wood and products of wood and cork	0.18	0.08	0.09	1.21
2122	Pulp, paper, paper products, printing and publishing	0.09	0.04	0.06	1.10
2325	Chemical, rubber, plastic and fuel products	0.15	0.06	0.06	1.17
2600	Other non-metalic mineral products	0.13	0.05	0.04	1.14
2728	Basic metals and fabricated metal products	0.19	0.11	0.14	1.23
2933	Machinery and equipment	0.06	0.07	0.45	1.06
3435	Transport equipment	0.04	0.11	0.73	1.04
3637	Manufactutring n.e.c.	0.12	0.06	0.12	1.13
6063	Transport and storage	0.10	0.06	0.18	1.11
6400	Post and telecommunication	0.29	0.13	0.08	1.42
6567	Financial intermediation	0.40	0.08	0.00	1.68
7074	Real estate, renting and business activities	0.33	0.06	0.00	1.50

Finland

ISIC code	Sector	B	Std. error	p-value	Mark-up
1516	Food Products, bevarages and tabaco	0.11	0.02	0.00	1.12
1719	Textiles, textile products, leather and footwear	0.10	0.03	0.00	1.11
2000	Wood and products of wood and cork	0.21	0.05	0.00	1.26
2122	Pulp, paper, paper products, printing and publishing	0.21	0.04	0.00	1.26
2325	Chemical, rubber, plastic and fuel products	0.17	0.03	0.00	1.21
2600	Other non-metalic mineral products	0.24	0.03	0.00	1.31
2728	Basic metals and fabricated metal products	0.15	0.02	0.00	1.18
2933	Machinery and equipment	0.18	0.03	0.00	1.22
3435	Transport equipment	0.12	0.05	0.04	1.13
3637	Manufactutring n.e.c.	0.16	0.02	0.00	1.18
6063	Transport and storage	0.29	0.02	0.00	1.41
6400	Post and telecommunication	0.37	0.02	0.00	1.58
6567	Financial intermediation	0.31	0.01	0.00	1.44
7074	Real estate, renting and business activities	0.44	0.02	0.00	1.78

France

ISIC code	Sector	B	Std. error	p-value	Mark-up
1516	Food Products, bevarages and tabaco	0.12	0.02	0.00	1.14
1719	Textiles, textile products, leather and footwear	0.06	0.02	0.00	1.07
2122	Pulp, paper, paper products, printing and publishing	0.12	0.01	0.00	1.14
2325	Chemical, rubber, plastic and fuel products	0.13	0.02	0.00	1.15
2600	Other non-metalic mineral products	0.14	0.04	0.00	1.16
2728	Basic metals and fabricated metal products	0.08	0.02	0.00	1.08
2933	Machinery and equipment	0.18	0.02	0.00	1.21
3435	Transport equipment	0.08	0.02	0.00	1.09
3637	Manufactutring n.e.c.	0.11	0.02	0.00	1.12
6063	Transport and storage	0.17	0.02	0.00	1.21
6400	Post and telecommunication	0.47	0.08	0.00	1.88
6567	Financial intermediation	0.22	0.04	0.00	1.29
7074	Real estate, renting and business activities	0.47	0.01	0.00	1.90

Italy

ISIC code	Sector	B	Std. error	p-value	Mark-up
1516	Food Products, bevarages and tabaco	0.11	0.01	0.00	1.12
1719	Textiles, textile products, leather and footwear	0.12	0.01	0.00	1.14
2000	Wood and products of wood and cork	0.12	0.01	0.00	1.14
2122	Pulp, paper, paper products, printing and publishing	0.14	0.01	0.00	1.16
2325	Chemical, rubber, plastic and fuel products	0.12	0.02	0.00	1.14
2600	Other non-metalic mineral products	0.19	0.01	0.00	1.24
2728	Basic metals and fabricated metal products	0.11	0.01	0.00	1.13
2933	Machinery and equipment	0.14	0.01	0.00	1.16
3435	Transport equipment	0.10	0.01	0.00	1.11
3637	Manufactutring n.e.c.	0.13	0.01	0.00	1.14
6567	Financial intermediation	0.28	0.02	0.00	1.40
7074	Real estate, renting and business activities	0.55	0.01	0.00	2.21

Note: Due to data availability, the sample period for Germany covers 1991-2001.

4. Aggregate Empirical Results

In section 4.1 we investigate whether product market competition, proxied by the level of mark-up, can explain cross-country variation in average inflation rates within the aggregate sample panel examined consisting of the 15 EU countries. In section 4.2 we investigate the robustness of these results.

4.1. Regression results

In order to investigate the link between product market competition and average inflation rates at an aggregate level we compute the averages of inflation rates and the explanatory variables for two decades, the 1980s and the 1990s[16]. We estimate a panel of 15 EU countries using a fixed effects (FE) estimation or random effects GLS estimation method (RE GLS) depending on the result of the Hausman test implemented. The Lagrange Multiplier test for random effects as suggested by Breusch-Pagan[17] (1980) is also reported. The main estimation results are reported in Table 5. The first column shows the FE estimation results of a baseline specification where inflation is explained by mark-up without any additional explanatory variables. In the second column we insert M3 growth to control for monetary policy developments and in the third column we add the logarithm of GDP per capita. Finally, in the fourth column we also add a measure of openness (export plus import over GDP) and control for country size. The third and fourth specifications are estimated using RE GLS.

In the first specifications (columns 1), mark-up is statistically significant at the 1% level and the estimated coefficients are always correctly signed, indicating a positive relationship between mark-up and inflation. Since higher mark-ups are associated with less competition, our findings suggest that lower product market competition is likely to be associated with higher inflation rates. Results are broadly confirmed when controlling for monetary policy developments in terms of M3 growth[18]. The estimated coefficient of mark-up is slightly less significant than in the first specification (column 2) but the goodness of fit in terms of R squared is significantly improving.

[16] In order to increase the number of observations available, we take the 1980-1990 and 1991-2001 averages instead of averages for the entire sample period as done in the sectoral analysis. Results obtained using averages over the 1980-2001 period basically confirm our findings.

[17] The null hypothesis of this test is $\sigma_{\mu}^{2} = 0$. It is worth to stress that results of this test should be treated with cautious given the potentially poor approximation of the test statistic in small samples (see Moulton and Randolph (1989) for a discussion).

[18] We do not control for monetary policy independence, as done for the sectoral sample covering the 1980-2001 period, given that separate data for the 1980s and 1990s are not available.

Table 5: Inflation explained by mark-up and a set of explanatory variables.

	1	2	3	4
Estimation Method	**FE**	**FE**	**RE, GLS**	**RE, GLS**
Constant	-10.9	-4.92	14.61	18.33
	(2.72)	(2.4)	(4.14)	(4.69)
	[0.0]	[0.05]	[0.03]	[0.0]
Mark-up	**8.12**	**2.90**	**2.96**	**2.56**
	(1.35)	**(1.47)**	**(1.36)**	**(1.36)**
	[0.0]	**[0.06]**	**[0.0]**	**[0.06]**
M3 growth		0.46		
		(0.09)		
		[0.0]		
Log GDP per capita			-5.8	-4.96
			(0.83)	(1.01)
			[0.0]	[0.0]
Openness				-0.016
				(0.014)
				[0.22]
log(GDP)				-0.73
				(0.45)
				[0.11]
R2	0.29	0.77	0.75	0.77
Breusch-Pagan	-	-	0.37	0.61
Hausman test	-	(0.02)	(0.11)	(0.53)

Note: standard errors are reported in parentheses and p-values in square brackets.

Adding the logarithm of GDP per capita, a proxy of the level of development in each country, does not affect the significance of the mark-up and considerably increases the goodness of fit in terms of R squared (see column 3 in Table 5) compared to the first specification. The coefficient on the logarithm of GDP per capita is negative and highly significant. This result is consistent with the notion that richer countries tend to have higher aversion for inflation and thus a lower optimal level of inflation tax (Lane (1997)). Controlling for country openness does not substantially change the results, with mark-up becoming slightly less significant and the fit of the model improving slightly (column 4 in Table 5). The estimated coefficient on openness is however not significant, contrary to earlier findings by Romer (1993) and Lane (1997)[19].

4.2. Robustness

In order to assess the robustness of the results reported in the previous section we repeat the analysis using three alternative proxies of product market competition. First, we substitute

[19] The same result is obtained using the ratio of nominal imports to nominal GDP as alternative proxy for openness.

mark-up with a measure of profit margin[20] and run the same set of regressions. Table **6** below shows the results of the estimations. The estimated coefficients for profit margin are correctly signed, however not statistically significant in the second specification. Results previously found for the other explanatory variables inserted are broadly confirmed.

Table 6: Inflation explained by profit margin and a set of explanatory variables.

	1	2	3	4
Estimation Method	**FE**	**FE**	**RE, GLS**	**RE, GLS**
Constant	-1.43	-15.25	18.21	21.3
	(1.36)	(9.6)	(3.17)	(3.42)
	[0.31]	[0.12]	[0.0]	[0.0]
Profit Margins	**0.28**	**0.09**	**0.10**	**0.10**
	(0.05)	**(0.05)**	**(0.05)**	**(0.05)**
	[0.00]	**[0.12]**	**[0.08]**	**[0.05]**
M3 growth		0.5		
		(0.09)		
		[0.00]		
Log GDP per capita			-5.8	-4.53
			(0.88)	(1.08)
			[0.0]	[0.0]
Openness				-0.02
				(0.013)
				[0.1]
log(GDP)				-0.90
				(0.44)
				[0.04]
R2	0.33	0.77	0.74	0.77
Breusch-Pagan	-	0.61	0.80	0.61
Hausman test	-	(0.04)	(0.33)	(0.67)

Note: standard errors are reported in parentheses and p-values in square brackets.

Second, we substitute mark-up with a measure of profit rate (net unadjusted operating surplus over capital stock) and run the same set of regressions[21]. Table 7 below shows the results of the estimations. Once we control for other explanatory variables, the rate of profit is not statistically significant anymore in explaining inflation (column 2 and 3).

[20] As described in detail in section 2.2, we have used the ratio of net operating surplus unadjusted for the imputed labour share of self-employed over GDP. We also repeated the analysis using gross unadjusted operating surplus over GDP obtaining similar findings.
[21] Due to data availability on the capital stock we had to exclude Germany from the panel.

Table 7: Inflation explained by the profit rate and a set of explanatory variables.

	1	2	3
Estimation Method	**FE**	**RE, GLS**	**RE, GLS**
Constant	-0.23	21.1	23.1
	(2.1)	(2.8)	(3.22)
	[0.9]	[0.0]	[0.0]
Profit Rate	**0.7**	**0.16**	**0.32**
	(0.26)	**(0.18)**	**(0.21)**
	[0.01]	**[0.4]**	**[0.12]**
Log GDP per capita		-6.47	-4.86
		(0.82)	(1.13)
		[0.0]	[0.0]
Openness			-0.03
			(0.02)
			[0.06]
log(GDP)			-0.97
			(0.51)
			[0.06]
R2	0.05	0.72	0.76
Breusch-Pagan	-	(0.48)	(0.81)
Hausman test	-	(0.51)	(0.26)

Note: standard errors are reported in parentheses and p-values in square brackets

Finally, as an additional robustness check we replace mark-up with an indicator of the intensity of local competition taken from the Global Competitiveness Report (2002). Given that this indicator is only available for one year, we decided to keep its value constant over the entire sample period. We therefore calculated averages of inflation and all the explanatory variables for the period 1980-2001 and performed standard OLS estimations. Since higher values of this indicator correspond to a more intense competition, we expect to find a negative coefficient. The estimation results shown in Table 8 reveal indeed a negative and statistically significant relationship. It should however be noted that the sample size of this specification is small and therefore the results should be treated with caution.

Table 8: Inflation explained by an indicator of intensity of competition and a set of explanatory variables. OLS estimations (1980-2001 average).

	1	2	3	4
Const	40.34	37.90	36.10	20.84
	(8.91)	(5.06)	(5.34)	(7.58)
	[0.01]	[0.00]	[0.00]	[0.03]
Intensity of local competition	-6.03	-3.27	-2.34	-1.48
	(1.53)	(1.03)	(1.31)	(1.11)
	[0.00]	[0.01]	[0.11]	[0.22]
Mark_up				3.07
				(1.29)
				[0.05]
Gdp per capita		-5.22	-4.96	-3.66
		(1.05)	-1.09	(1.02)
		[0.00]	[0.00]	[0.01]
Openess			-0.02	-0.02
			(0.02)	(0.03)
			[0.23]	[0.13]
Size			-0.41	-0.36
			(0.47)	(0.38)
			[0.41]	[0.36]
R-squared	0.58	0.88	0.90	0.95

Note: standard errors are reported in parentheses and p-values in square brackets.

The results presented in this section confirm our findings of a negative relationship between product market competition and average inflation rates. Countries with more competitive markets tend to have on average lower inflation rates. Comparison of the explanatory power of the different proxies of competition examined reveals that the mark-up appears to be the best proxy while profit margin, the profit rate and the intensity of local competition seem to perform less satisfactorily. In particular, the indicator of the intensity of local competition looses its significance after the inclusion of mark-up (column 4 in Table 8), implying that the mark-up alone is sufficient to capture the effect of competition.

5. Sectoral Empirical Results

We extend now the empirical analysis carried out in section 4 for the aggregate economy to a sectoral level using the OECD STAN database. Our main interest is to investigate whether the results obtained at the aggregate level, showing that a higher intensity of product market competition leads to lower average inflation rates, still hold at the sectoral level. Intuitively, different economic sectors could react asymmetrically to the degree of product market competition and therefore the relation between competition and inflation rates at the sectoral level may differ when compared to the aggregate level. In section 5.1 below we present the main empirical findings and in section 5.2 we implement robustness checks.

5.1. Sectoral Results

Our panel consists of 8 countries and 14 sectors (see section 3 and Appendix 8.1.2 for a detailed description of the data used). Due to data availability we include only a limited number of countries in the sectoral panel in comparison with the aggregate panel used in section 4 consisting of the EU 15 countries. However, the countries included represent approximately 68% of the total average EU 15 GDP in the period 1980-2001.

First of all, we run model [4] as described in section 2.3 using as a proxy of competition the level of sectoral mark-up. Results are reported in Table 9 below. The Lagrange Multiplier test for random effects as suggested by Breusch-Pagan (1980) is also reported. We also implement a Hausman (1978) test to check the correct specification of our model, namely that the $\mu_i's$ are uncorrelated with the $X_i's$. If this is the case and the null hypothesis is accepted, then the random effects GLS (RE GLS) estimation can be correctly implemented[22].

Table 9: Inflation explained by mark-up and a set of explanatory variables.

	1	2	3a	3b	4	5	6	7	8	9	10	11
Estimation Method	**FE**	**RE, GLS**	**RE, GLS**	**RE, GLS**	**RE, GLS**	**RE, GLS**	**RE, GLS**	**RE, GLS**	**RE, GLS**	**RE, GLS**	**RE, GLS**	**RE, GLS**
Constant	2.92	21.09	20.86	2.52	-2.60	-1.16	0.54	-3.01	17.12	17.23	18.83	16.86
	(0.45)	(3.62)	(3.98)	(11.73)	(3.44)	(2.68)	(2.91)	(3.55)	(4.8)	(3.53)	(3.52)	(4.85)
	[0.0]	[0.0]	[0.0]	[0.82]	[0.45]	[0.66]	[0.85]	[0.4]	[0.0]	[0.0]	[0.0]	[0.0]
Mark up	**0.56**	**0.57**	**0.56**	**0.58**	**0.57**	**0.57**	**0.58**	**0.57**	**0.56**	**0.55**	**0.56**	**0.55**
	(0.22)	**(0.23)**	**(0.23)**	**(0.22)**	**(0.23)**	**(0.23)**	**(0.23)**	**(0.23)**	**(0.23)**	**(0.23)**	**(0.23)**	**(0.23)**
	[0.02]	**[0.01]**	**[0.01]**	**[0.01]**	**[0.01]**	**[0.01]**	**[0.01]**	**[0.01]**	**[0.01]**	**[0.02]**	**[0.01]**	**[0.02]**
Log GDP per capita		-6.79	-6.44	-1.81					-6.13	-6.17	-6.73	-6.08
		(1.32)	(1.61)	(3.22)					(1.38)	(1.11)	(1.18)	(1.37)
		[0.0]	[0.0]	[0.57]					[0.0]	[0.0]	[0.0]	[0.0]
Central Bank Independence (col.3a) / M3 (col.3b)			-1.86	0.62								
			(3.81)	(0.38)								
			[0.62]	[0.10]								
Economic regulation					2.51				1.02			
					(1.50)				(0.84)			
					[0.01]				[0.23]			
Regulation of competition						3.55				1.94		
						(2.17)				(1.0)		
						[0.1]				[0.05]		
Barriers to competition							1.95				1.74	
							(2.27)				(1.09)	
							[0.39]				[0.11]	
State control								2.38				0.94
								(1.37)				(0.77)
								[0.08]				[0.22]
R^2	0.06	0.62	0.62	0.66	0.26	0.24	0.11	0.27	0.65	0.67	0.67	0.65
Breusch-Pagan		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Hausman	-	(0.80)	(0.87)	(0.16)	-	-	-	-	(0.83)	(0.72)	(0.96)	(0.77)
Alternative Specification Test	(0.03)	(0.65)	(0.74)	(0.27)	(0.23)	(0.16)	(0.06)	(0.27)	(0.64)	(0.55)	(0.92)	(0.54)

Note: standard errors are reported in parentheses and p-values in square brackets.

[22] In some of the models estimated the asymptotic assumptions of the Hausman test are not met and the test cannot be performed. In such cases we have implemented and reported an alternative test, which we refer to as "Alternative specification Test" in the tables. This simple test is computed adding and subtracting in the random effect specification the average of each exogenous variable and comparing the estimated coefficients of the averaged variable with that of the deviation of each exogenous variable from its mean. If these two estimated coefficients are the same (null hypothesis of the test), a fixed effects estimation does not add information over the random effects specification which can be considered correctly specified. The results of the Hausman test (when computable) always confirm those of the alternative specification test reported.

Column 1 of Table 9 shows the results of the basic model making use of the sectoral mark-up. Applying fixed-effects (FE) we find that the mark-up is statistically significant at the 5% level and the estimated coefficient is correctly signed (column 1). However, the R squared is low. Adding the logarithm of GDP per capita (column 2) and applying RE GLS, the mark-up is significant at the 1% level and the logarithm of GDP per capita is also statistically significant and its coefficient is correctly signed (negative). These results confirm the findings obtained at the aggregate level. Moreover, quite interestingly, adding GDP per capita significantly improves the fit of the model in terms of R squared. Given that the logarithm of GDP per capita is a country specific variable within our sectoral panel, this result suggests that the bulk of the variation in sectoral inflation rates in the sample examined is driven by country specific effects. This result is confirmed by regressing the inflation rates with country or sector specific dummies separately. Sectoral dummies are in general not statistically significant and they explain only a small part of the variation in the data whilst country dummies are significant and explain a large proportion of the variation in the data.

In column 3a of Table 9 we control for central bank independence using a measure of central bank legal independence computed by Cukierman (1998). The intuition is that a different degree of central bank independence across countries may have influenced average inflation. In particular, less independent central banks may have an incentive to set actual inflation above target inflation (see for example Cukierman et al. (1992)). Consistent to previous findings (Miron and Campillo (1997), Neiss (2001) and Cavelaars (2003)), central bank legal independence is not statistically significant in explaining average inflation rates over a long time horizon. Most importantly, the findings confirm the results of the basic specification with mark-up being still statistically significant at the 1% level[23]. Given that central bank independence does not appear to be statistically significant, in column 3b we control for monetary policy using the growth rate of M3 which is correctly signed but statistically significant only at the 10% level. Mark-up continues to be statistically significant in explaining average inflation rates.

In columns 4 to 7 of Table 9, we report results when we add country specific indicators of product market institutions in the models. Mark-up continues to be statistically significant even controlling for other measures of market regulation, namely economic regulation, regulation of competition, barriers to competition and state control. These indicators are generally not statistically significant. It is worth stressing that these results should be taken with great caution given that all indicators of market regulation are available for 1998 only

[23] As a robustness test we have also investigated the significance of a variable measuring the length of central bank independence, computed as the number of years since a central bank achieved legal independence. This variable is also not statistically significant and the results obtained for the basic specification are confirmed.

and this observation is used for the entire sample considered. Finally, we repeat the estimations adding log of GDP per capita (column 8 to 11) and our results are confirmed.

As an additional exercise we perform some simulations using the estimation results obtained in Table 9 column 2 and Table 5 column 3 (aggregate sample), i.e. using the model specifications which make use of mark-up and the logarithm of GDP per capita. An increase in competition resulting from a 10% reduction in mark-up would induce an average reduction in the long-term inflation rate by 0.6% in the aggregate sample and by 0.1% in the sectoral sample. These simulations have to be taken with great caution and should be considered more as an illustration than as an estimate. In particular, the difference in the results between the aggregate and the sectoral sample may also be linked to the fact that average inflation is higher in the aggregate sample due to a different country coverage[24]. In the aggregate sample covering the 15 EU countries, average inflation in the period 1980-2001 is 5.2% compared to an average of 3.9% in the sectoral sample consisting of 8 countries. Moreover, it is worth stressing that the quantitative simulations described refer to an average over countries and time (1980-2001), implying that results may differ significantly for each country or considering a different time horizon.

5.2. Robustness

As for the aggregate sample, we repeat the estimations using as alternative proxy of product market competition sectoral profit margin. Results are reported in Table 10 below. Sectoral profit margin is not statistically significant in explaining average inflation rates (column 1). Moreover, given that RE GLS estimation is not appropriate in most of the specifications, performing FE estimation has the disadvantage that country specific explanatory variables, that are the same across sectors, are dropped from the estimation. However, when RE GLS can be implemented, (column 5 and 6), other indicators of regulation such as regulation of competition and barrier to competition seem to perform better than profit margin in explaining average inflation rates. In these specifications profit margin continues not to be statistically significant in explaining average inflation. One of the reasons for the poor performance of profit margin as a proxy of competition at the sectoral level could be the fact that, due to data limitations, profit margins are computed using gross rather than net operating surplus (see Appendix 8.1.2). Gross operating surplus includes the consumption of fixed capital (reduction in the value of assets over time) which varies across sectors due, for example, to the different degree of capital intensity. Using gross operating surplus could therefore introduce some distortions in the measurement of profit margin in some sectors.

Table 10: Inflation explained by profit margin and a set of explanatory variables. Random effects GLS estimations.

	1	2	3	4	5	6	7	8	9	10	11
Estimation Method	**FE**	**FE**	**FE**	**FE**	**RE, GLS**	**RE, GLS**	**FE**	**FE**	**FE**	**FE**	**FE**
Constant	2.51	2.51	2.51	2.51	-0.80	-0.21	2.51	2.51	2.51	2.51	2.51
	(0.54)	(0.54)	(0.54)	(0.54)	(0.88)	(1.19)	(0.54)	(0.54)	(0.54)	(0.54)	(0.54)
	[0.0]	[0.0]	[0.0]	[0.0]	[0.36]	[0.86]	[0.0]	[0.0]	[0.0]	[0.0]	[0.0]
Profit margins	**1.61**	**1.61**	**1.61**	**1.61**	**2.02**	**1.94**	**1.61**	**1.61**	**1.61**	**1.61**	**1.61**
	(1.24)	**(1.24)**	**(1.24)**	**(1.24)**	**(1.25)**	**(1.26)**	**(1.24)**	**(1.24)**	**(1.24)**	**(1.24)**	**(1.24)**
	[0.2]	**[0.2]**	**[0.2]**	**[0.2]**	**[0.11]**	**[0.13]**	**[0.2]**	**[0.2]**	**[0.2]**	**[0.2]**	**[0.2]**
Log GDP per capita		dropped	dropped					dropped	dropped	dropped	dropped
Central Bank Independence / M3 growth			dropped								
Economic regulation				dropped				dropped			
Regulation of competition					2.72				dropped		
					(0.64)						
					[0.0]						
Barriers to competition						2.14				dropped	
						(0.86)					
						[0.01]					
State control							dropped				dropped
R^2	0.11	0.11	0.11	0.11	0.40	0.28	0.11	0.11	0.11	0.11	0.11
Breusch-Pagan					(0.01)	(0.00)					
Hausman	-	-	-	-	(0.00)	-	-	-	-	-	-
Alternative Specification Test	(0.00)	(0.00)	(0.00)	(0.01)	(0.11)	(0.14)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)

Note: standard errors are reported in parentheses and p-values in square brackets.

To further explore the robustness of our results, we test as an alternative measure of product market competition the intensity of local competition measured by the World Economic Forum. Given that this proxy of competition is not available over the sample period considered, we use available data for 2001 for the entire sample. Notwithstanding this data limitation, the measure of intensity of competition proves to be highly significant in all the specifications chosen (see Table 11 column 1 to 3), confirming the results obtained for the aggregate panel.

Finally, we add to the county and sector dimensions examined so far in the sectoral panel a temporal dimension. As done in the aggregate sample, we compute the average inflation rates in the period 1980-1990 and 1991-2001. Taking averages of 10 years for the inflation rates we remove cyclical fluctuations and we are able to test the stability over time of the relationship between inflation rates and product market competition. To this end, we include a time dummy variable in the models[25]. Results of FE estimations are reported in Table 11 below (column 4 and 5) and confirm the main findings obtained. Adding a temporal dimension, mark-up is still highly significant in explaining average inflation rates also when adding log of GDP per capita.

[24] Moreover, different measures of inflation have been used at the aggregate and sectoral level (see Appendix 8.1).

[25] An alternative, computationally more costly way to deal with a panel with three dimensions (countries, sectors and time) is also suggested in Hsiao (2003) pg. 302 and consists of transforming the data in order to apply a GLS estimator to the "re-scaled" set of data.

Table 11: Inflation explained by an indicator of intensity of competition (column 1 to 3) and inflation explained by the mark-up within a tri-dimensional panel (country-sector-time).

	1	2	3	4	5
Sample	1980-2001 average			Panel t=2	
Estimation method	**LSDV**	**RE, GLS**	**RE, GLS**	**FE**	**FE**
Constant	102.46	36.03	34.33	11.56	32.50
	(8.02)	(4.36)	(4.85)	(0.66)	(3.23)
	[0.0]	[0.0]	[0.0]	[0.0]	[0.0]
Mark-up			**0.56**	**0.51**	**0.49**
			(0.23)	**(0.2)**	**(0.18)**
			[0.01]	**[0.01]**	**[0.01]**
Log GDP per capita		-5.63	-5.48		-12.28
		(0.83)	(0.92)		(1.86)
		[0.0]	[0.0]		[0.0]
Intensity of competition	-17.29	-2.95	-2.90		
	(1.44)	(0.85)	(0.94)		
	[0.0]	[0.0]	[0.0]		
Country dummy	yes	-	-	-	-
Time dummy	-	-	-	yes	yes
R^2	0.72	0.69	0.70	0.38	0.70
Breusch Pagan	-	0.27	0.23	-	-
Hausman	-	-	0.91	-	0.07
Alternative Specification Test				0.00	0.00

Note: standard errors are reported in parentheses and p-values in square brackets.

Finally, for the limited number of countries and sectors available, we use the estimated sectoral mark-up reported in Table 4 as an explanatory variable. We find however that this indicator is not statistically significant in explaining average inflation rates. One possible reason for this result may be the limited number of observations in the sample considered and, to a certain extent, the methodological caveats related to the mark-up estimation mentioned in section 2.2. A possible extension of this work could be to try to overcome the data limitation, especially on the capital stock side, in order to increase the number of countries and sectors in the panel.

6. Conclusions

In this paper we investigate the link between product market competition, measured by alternative proxies, and long-term average inflation rates. We examine first a panel consisting of 15 EU countries at the aggregate level and then a sectoral panel for 8 EU countries.

Results for both panels show that the extent of product market competition is an important driver in explaining average inflation rates across countries and sectors. In particular, our findings suggest that higher product market competition reduces average inflation rates for a prolonged period of time, thus empirically confirming the rationale of our investigation. The negative relationship between competition and average inflation continues to hold when controlling for country size, monetary policy developments, country openness and the level of country development. Moreover, results both at the aggregate and sectoral level are generally confirmed by a wide set of robustness tests. This entails both testing for alternative proxies of product market competition and for different specification of the estimation models.

Notwithstanding the empirical difficulties in measuring product market competition and the fact that none of the proxies of competition used are free from possible limitations, we can conclude that amongst the proxies used mark-up, measured as the inverse of the labour income share, performs best in explaining average inflation rates both at an aggregate and a sectoral level. This is confirmed by testing a wide range of alternative proxies for product market competition (the profit margin, the profit rate and a qualitative indicator measuring the intensity of competition). We also estimate sectoral mark-up econometrically following Martin et al (1996) obtaining broadly similar results. Data limitations on the capital stock however limit the scope of our exercise. Furthermore, indicators of product market regulations are, in general, not statistically significant in explaining average inflation rates at a sectoral level.

Regarding the sectoral analysis, we find that the bulk of the variation in inflation rates can be explained by "country specific effects" whilst "sectoral effects" seem to play only a minor role. A tentative explanation of this result could be that country specific factors, such as the level of country development or the extent to which country specific monetary policy influence the pricing behaviour of firms, are likely to affect the entire economy rather than some specific sectors. Further investigation in this area could be an interesting field for future research with the aim of defining and testing other sector specific proxies of competition. Another interesting extension of this analysis would be the inclusion of non EU countries in the panel.

The policy implications of this paper are twofold. First, the empirical evidence that higher product market competition leads to lower average inflation rates for a prolonged period of time appears to be robust and confirms previous findings. Second, the claim of policy makers and central banks to urge progress in product market reforms is supported by the fact that this is likely to lead to a permanently lower level of inflation.

It is worth stressing that conclusions should be cautiously assessed given that in the sample period considered, 1980-2001, some other factors affecting inflation and going beyond the effect of product market competition might have played a role. Amongst those factors a major one was the introduction of the Single Market in 1992. Moreover, average inflation rates in the sample period examined were significantly higher than in the euro area or in the EU now and this is likely to imply that the policy conclusions drawn may be less stringent in a "low inflation environment".

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8. Appendix

8.1. Data Description

8.1.1. Aggregate Data

Countries: 15 EU Countries.

Variables used:

Inflation = $\log(\text{GDP deflator})_t - \log(\text{GDP deflator})_{t-1}$

Mark-up = GDP / Compensation of employees

Profit margin = Net operating surplus (unadjusted) / GDP

Profit rate = Net operating surplus (unadjusted) / Capital Stock

Openness = Nominal Exports + Nominal Imports / Nominal GDP

Size = log(Nominal GDP)

log(GDP per capita)

Source: European Commission AMECO database

M3 = growth rate of M3 excluding currency in circulation (Source: National Central Banks, ECB).

"Intensity of competition" is taken from the Global Competitiveness Report 2001-2002 published by the World Economic Forum and refers to the year 2001.

Data for Germany prior to the unification was calculated using growth rates derived from West Germany data.

8.1.2. Sectoral data

Countries: Austria, Germany, Denmark, Finland, France, Italy, Portugal, Sweden.

Sectors (according to ISIC Rev.3) comprise both manufacturing and non-manufacturing sectors at the 2-digit level:

Sector code	Description
1516	Food products, beverages and tobacco
1719	Textiles, textile products, leather and footwear
2000	Wood and products of wood and cork
2122	Pulp, paper, paper products, printing and publishing
2325	Chemical, rubber, plastics and fuel products
2600	Other non-metal mineral products
2728	Basic metal and fabricated metal products
2933	Machinery and equipment
3435	Transport equipment
3637	Manufacturing n.e.c
6063	Transport and storage
6400	Post and telecommunication
6567	Financial intermediation
7074	Real estate, renting and business activities

Variables used (with STAN notation):

Value added deflator = (VALU / (VALK * VALK [1995])) * 10000

Inflation = log (Value Added deflator)$_t$ – log (Value Added deflator)$_{t-1}$

Mark-up = VALU / LABR

Profit margin (unadjusted) = OPSM / VALU

Source: OECD sectoral database STAN

We use gross rather than net profit margin, because of limited data availability and the use of different methodologies across countries to calculate fixed capital consumption.

Overall economic regulation, regulation of competition, barrier to competition and state control are from Nicoletti, Scarpetta and Boyland (2000) and refer to 1998.

Central banks legal independence is taken by Cukierman (1998), Table 19.3.

Data for Germany prior to the unification was calculated using growth rates derived from West Germany data.

8.1.3 Estimation of mark-up

a) Construction of variables

Gross value added (VALU)

dv = ln(VALU)-ln(VALU)[_n-1]

Gross capitak stock (CAPK)

dk = ln(CAPK)-ln(CAPK)[_n-1]

Gross fixed capital deflator

GFCD = dGFCF/dGFCK

Rental price of capital (R)

R = ((i-infl. expect.) + 5%)*GFCD

dr = ln(R) – ln(R)[_n-1]

Total employment (EMPN)

dl = ln(EMPN)-ln(EMPN)[_n-1]

Employees (EMPE)

Compensation of employees (LABR)

Compensation per employee LABR/EMPE

dw = ln(LABR/EMPE)-ln(LABR/EMPE)[_n-1]

Labour input share

a = [EMPN(LABR/EMPE)]/PROD

Intermediate inputs:

Inputs=PROD-VALU

dn=ln(inputs)-ln(inputs[_n-1])

Intermediate inputs share

b=(PROD-VALU)/PROD

b) Final equation to estimate

dy = B.dx + error term

where:

dy=dv-a(dl+dw)-b(dn)-(1-a-b)(dk+dr)

dx=dv-(dk+dr)

and mark-up = 1/(1-B)

c) Calculated mark-up is available for the following countries and sectors:

Country	Start	End	Sectors
DEU	1991	2002	All
DNK	1970	2002	All
FIN	1975	2002	All
FRA	1970	2001	All, except 2000
ITA	1980	2000	All, except 6063, 6400

9. Annex Tables

Annex Table 1. Aggregate sample: correlation between different measures of profit margin and other proxies of competition

	Net operating surplus (unadjusted[1]) as % of GDP	Net operating surplus (adjusted[2]) as % of GDP	Gross operating surplus (unadjusted[1]) as % of GDP	Gross operating surplus (adjusted[2]) as % of GDP
Mark-up	0.97	0.63	0.96	0.24
Intensity of competition	-0.55	-0.15	-0.57	0.07

1) Unadjusted for imputed labour income of the self-employed
2) Adjusted for imputed labour income of the self-employed

Annex Table 2. Aggregate sample: correlation between inflation and different proxies of competition

	Inflation
Mark-up	0.85
Net operating surplus (unadjusted[1]) as % of GDP	0.79
Net operating surplus (adjusted[2]) as % of GDP	0.37
Gross operating surplus (unadjusted[1]) as % of GDP	0.81
Gross operating surplus (adjusted[2]) as % of GDP	0.04
Intensity of competition	-0.76

1) Unadjusted for imputed labour income of the self-employed
2) Adjusted for imputed labour income of the self-employed

Annex Table 3. Sectoral sample: correlation between different measures of profit margin and other proxies of competition

	Gross operating surplus (unadjusted[1]) as % of production	Gross operating surplus (adjusted[2]) as % of production	Gross operating surplus (unadjusted[1]) as % of value added	Gross operating surplus (adjusted[2]) as % of value added
Mark-up	0.07	0.03	0.43	0.35
Intensity of competition	-0.14	-0.10	-0.33	-0.24
Economic regulation	0.06	0.00	0.24	0.09
Barriers to competition	0.09	0.06	0.26	0.19
Regulation of competition	0.07	0.00	0.27	0.13
State control	0.05	-0.02	0.24	0.08

1) Unadjusted for imputed labour income of the self-employed
2) Adjusted for imputed labour income of the self-employed

Annex Table 4. Sectoral sample: correlation between inflation and different proxies of competition

	Inflation
Mark-up	0.34
Gross operating surplus (unadjusted[1]) as % of production	0.19
Gross operating surplus (adjusted[2]) as % of production	0.13
Gross operating surplus (unadjusted[1]) as % of value added	0.34
Gross operating surplus (adjusted[2]) as % of value added	0.23
Intensity of competition	-0.59
Economic regulation	0.61
Barriers to competition	0.49
Regulation of competition	0.61
State control	0.62

1) Unadjusted for imputed labour income of the self-employed
2) Adjusted for imputed labour income of the self-employed

Annex Table 5. Sectoral sample: Sample statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Inflation	112	3.946469	3.49881	-6.81889	13.72926
Mark-up (VA)	112	1.820744	0.797018	1.022296	6.058326
Profit margin (VA)	82	0.40762	0.150769	0.16614	0.999538
Log(GDP per capita)	112	2.675892	0.390104	1.702312	2.987139
Intensity of competition	112	5.75	0.3825	5.3	6.3
Economic regulation	112	2.487375	0.698377	1.51	3.923
Barriers to competition	112	1.203875	0.421141	0.303	1.746
Regulation of competition	112	2.195875	0.637022	1.35	3.495
State control	112	1.14325	0.432298	0.513	1.966

Annex Table 6. Sectoral sample: Correlations.

	Inflation	Mark-up	Profit margin	Log(GDP per capita)	Intensity competition	of Economic Regulation
Inflation	1					
Mark-up	0.3213	1				
Profit margin	0.3387	0.7996	1			
Log(GDP per capita)	-0.2969	-0.2069	0.0049	1		
Intensity of competition	-0.5855	-0.0722	-0.3334	0.095	1	
Economic Regulation	0.6058	0.1619	0.2397	-0.6677	-0.7352	1

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