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Price-cost mark-ups in UK industry

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Abstract: This paper tests for the presence of monopolistic price markups across UK industrial sectors by testing for a non-zero covariance between the Solow residual and various instruments. This follows the methodology of Hall (1988). We find evidence of significant markups in the Manufacturing and Services sectors which together account for more than 90% of total employment within the UK.

Keywords: Price-cost mark-up, monopoly power.

JEL classification: D43; L16

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I. Introduction

The relationship between monopoly power and the business cycle has been a topic of interest for macroeconomics for many years. Papers such as Rotemberg and Woodford (1992) and Gali (1994) have addressed this from a neo-classical theory perspective. These papers concentrate on the relationship between the price-cost mark-up and the business cycle and argue that there is a complex bi-directional relationship between the ability of firms to price above marginal cost and the overall level of economic activity. There has also been a long running theme in the Kaleckian tradition which has seen monopoly power as central to explaining key macroeconomic features such as business cycles and the distribution of income. Examples of this are Kalecki (1938) and Cowling (1982). A central theme of all this work is that market power is the norm rather than the exception for developed economies. Ultimately this is an empirical question which has been addressed in a number of different ways. The aim of this paper is to examine whether Hall's (1988) approach to testing for market power offers insights for the UK economy. In particular, we examine whether this approach detects deviations from competition similar to those detected by Hall for the US economy.

Empirical work in this area is made difficult because the direction of causality between monopoly power and economic activity is not clear. However, a notable contribution is that of Hall (1988) who uses sectoral data to test for the existence of market power at both the one-digit and two-digit levels for the US economy. This paper establishes a strong case for the importance of imperfect competition across a wide range of US industry with significant implications for the cyclical relationship between output and employment. In particular, his tests rely on the fact that labour input varies much less than output in response to business cycle fluctuations. More recent work by Afonso and Costa (2013) and Afonso and Jalles (2016) has demonstrated that the relationship between the price-cost mark-up and changes in output depends on whether output changes are the result of demand or supply shocks.

II. The Model

We assume a representative imperfectly competitive firm with production function:

$$Q_t = Ae^{\theta t} F(N_t, K_t) \quad (1)$$

where Q is output, N and K are labour and capital inputs respectively, F is a constant returns production function and θ is the exogenous rate of Hicks neutral technical progress. The marginal cost of production is given by:

$$c = \frac{w dN + r dK}{dQ - \theta Q} \quad (2)$$

where w and r are the marginal user costs of labour and capital and the prefix d indicates a small increment in a variable. Under constant returns to scale $wN + rK = cQ$. Using this property and defining the price-cost mark-up as $\mu = p/c$ and labour's share in total revenue as $\alpha = wN/pQ$ allows us to write:

$$\frac{dQ}{Q} = \frac{wN}{cQ} \frac{dN}{N} + \left(1 - \frac{wN}{cQ}\right) \frac{dK}{K} + \theta = \mu\alpha \frac{dN}{N} + (1 - \mu\alpha) \frac{dK}{K} + \theta \quad (3)$$

which can, in turn, be rewritten as:

$$\frac{dQ}{Q} - \alpha \frac{dN}{N} - (1 - \alpha) \frac{dK}{K} = (\mu - 1)\alpha \left(\frac{dN}{N} - \frac{dK}{K}\right) + \theta \quad (4)$$

The left-hand side of (4) is the conventionally measured Solow residual or the rate of growth of total factor productivity. Under competition $\mu = 1$ and therefore (4) would yield the standard result that total factor productivity growth is driven solely by the exogenous rate of technical progress. If, however, firms possess some degree of monopoly power then $\mu > 1$ and total factor productivity growth is positively related to the growth rate of the labour-capital ratio. Note that, in the presence of market power, the Solow residual is not synonymous with the rate of Hicks neutral technical progress, even when the production function exhibits constant returns to scale.

Let us define y_t as the Solow residual and x_t as the rate of change of the labour-capital ratio. Next, assume that the rate of technical progress is a stationary random variable such that $\theta_t = \theta + u_t$ where θ is the mean rate of technical progress and u_t is a random variable. We also introduce a t subscript for the mark-up ratio μ to allow for the possibility of a time-varying mark-up as discussed by Hall (1988). Taken together these modifications enable us to write equation (4) as:

$$y_t = (\mu_t - 1)\alpha_t x_t + \theta + u_t \quad (5)$$

This takes the form of a standard regression equation with the intercept being equal to the rate of exogenous technical progress and the slope coefficient being a function of the price-cost mark-up and labour's share in marginal cost. If the mark-up and labour share were fixed then estimation of (5) would provide a direct test for imperfect competition.

III. The Data

The estimates in this paper are based on output, employment and capital services data at the level of industrial sectors. The sectors considered are Agriculture; Mining and Quarrying, Manufacturing; Construction; Electricity, Gas and Water and Services. Together, these comprise the whole of UK GDP. This level of aggregation was chosen because it was possible to obtain long-runs of annual data at this level whereas lower levels of aggregation proved to be problematic because of missing data and a number of changes in the industrial classification system over the period considered.

Output data for 1990-2015 were taken from the ONS website. These are constant value measures expressed in index form. Longer time series were obtained by splicing these to the 1948-1998 indices of Gross Value Added by category of output given in the *Economic Trends Annual Supplement* for 1999 (Table 1.9). Consistent long runs of data for labour input are harder to obtain. Ideally, we would like to use an input measure based on hours but this proved impossible and instead we rely on data for numbers of employees /jobs. Prior to 1978 the data are based the assumption that each individual worker is based solely in one sector. Post 1978 the data are based on workforce jobs rather than individual workers. This means that individual workers can be counted multiple times if they hold more than one job and can also be counted in more than one sector. Since the post 1978 data is more reliable, we use this as the basis for the employment measure and splice this to data for employment by sector taken from the *Annual Abstract for Statistics* for various years. Even here, there are a number of breaks within the series due to changes in the Standard Industrial Classification. The employment data therefore consist of actual numbers of workforce jobs post 1978 but the pre-1978 figures are best thought of as an index with the 1978 figure acting as a base. Despite these caveats, we feel that the employment data give a reasonable indication of long-term trends in the distribution of employment between sectors as well as the year on year changes in employment by sector.

The mean growth rates of output and employment by sector are shown in Table 1 along with their standard deviations. These calculations are illustrative of some well-known trends in the UK economy in that they indicate a general increase in output across all sectors (with the exception of Mining and Quarrying) but a shift in employment from the traditional production sectors towards the service sector.

The capital input series used here are sectoral estimates taken from the ONS website. These are described by the ONS as “*tak(ing) account of quality and use of the capital stock across time and different types of asset*”. We believe this gives a better measure of capital input than the traditional capital stock measure (calculated by accumulating gross fixed investment) since it attempts to capture the flow of capital services rather than simply the level of installed capital. However, there are some associated problems. In particular, the ONS gives a combined capital services index for Agriculture and Mining. Also, the figures for Services are divided into a number of sub-categories. There is nothing we can do about the first problem but the Services indices have been combined into a single weighted index using weights derived as the share in employment taken from the input-output tables obtained from the ONS website. Note that average capital service growth is positive across all sectors – even the declining Mining and Quarrying sector. Note also, that the ONS capital services index is quite volatile in comparison with measures based on installed capital stock.

In addition to the descriptive statistics shown in Table 1, we have also investigated the relationship between the different sectors using the correlation coefficients shown in Table 2. Figures in bold indicate the correlation of year on year changes in output while the figures in italics give the correlation in the Solow residuals. These estimates indicate important linkages between the Manufacturing, Construction and Services sectors with strong positive correlations between annual changes of output within these sectors and rather lower, but still positive, correlations between their Solow residuals.

IV. Testing for monopoly power

If μ_t and α_t were fixed constants, then equation (5) would offer a simple test for the existence of monopoly power through a simple regression of the Solow residual on the rate of change of the capital-labour ratio. Under competition the slope coefficient should be zero whereas, in the presence of market power, it will be positive. However, there is no guarantee that these parameters will be fixed. Moreover, there is good reason to believe that changes in the capital-labour ratio may be correlated with random changes to productivity which would imply that estimates of the slope coefficient would be both biased and inconsistent. Hall (1988) proposes an alternative test based on an instrumental variable approach. Let z_t be an

instrumental variable with the properties $\text{cov}(u_t, z_t) = 0$ and $\text{cov}(x_t, z_t) \neq 0$. The covariance is estimated by performing an instrumental variable regression of the form (5) with the test statistic being the t-ratio for the slope coefficient. Under the joint assumptions that $\mu_t = 1$ and there are constant returns to scale then the covariance of the Solow residual and the instrument is equal to zero. We can test this by estimating (5) by the method of instrumental variables and testing the restriction that the slope coefficient is equal to zero. Note that the data used in all regressions are annual percentage changes in the relevant variables. Although the original series are integrated of order 1, the use of percentage changes means that the variables in the regression equations are stationary.

In practice we use three instruments: the rate of change of US Gross Domestic Product, the rate of change of UK Exports and the rate of change of US Exports (all series in constant prices). These were chosen on the basis that they are likely to be correlated with aggregate UK economic activity but not correlated with the error term in equation (5). The labour share α is measured as the ratio of compensation of employees to net value added which is taken from the UK input-output tables for 2013. Ideally, we would measure this ratio on an annual basis but such data are not available for the full time period. However, changes in α have a relatively minor effect on the Solow residual when compared with changes in the employment and capital inputs and we believe that the use of a fixed α estimate has very little effect on the results. The results, in the form of the p-values for the null hypothesis that the slope coefficient is equal to zero, are presented in Table 3. The estimates are for the period 1952 to 2014. The 2015 observation could not be used because our real US export series ended in 2014. Our results show rejection of the null hypothesis for the Manufacturing and Services sectors however, we fail to reject the null hypothesis for any of the other cases considered. Taken together, the Manufacturing and Services sectors account for more than 90% of total employment in the UK and therefore our evidence is consistent with the view that imperfect competition (or possibly increasing returns to scale) is a widespread phenomenon for UK economic activity.

It should be noted that our results may be sensitive to the problem of weak instruments. To test for this we present the F-statistic from a first stage regression of the right-hand side variable on a constant and the three instruments. Under the null hypothesis that the instruments are not significant this statistic is distributed as $F_{3,60}$ and the 5% critical value is 2.758. We do not reject the null in any of the cases examined here. On this basis, the failure to reject the null of $\mu_t = 1$ may reflect the use of weak instruments rather than genuinely competitive markets.

If we assume that the mark-up ratio μ is constant, then it is possible to estimate it using equation (5). However, Hall (1988) recommends estimating its reciprocal using a two-stage least squares regression of the reverse regression. This is because the instruments will tend to be more correlated with $\Delta(q/k)$ than $\Delta(n/k)$ when there is either labour hoarding or overhead labour is important (cf. Hall (1988) p. 934) for a fuller explanation). The reverse regression is therefore likely to produce more precise estimates when two-stage least squares is applied. Table 4 reports estimates of the slope coefficient from a reverse regression along with estimates of the implied mark-up ratio. The results are consistent with the hypothesis that the mark-up ratio is significantly greater than one in both the manufacturing and services sectors. Adjustment for serial correlation in the case of manufacturing produces virtually no change in the point estimate of the slope coefficient or its standard error. Note that this approach also allows us to calculate an indirect estimate of the rate of Hicks neutral technical progress θ which is positive in all cases except for the Electricity, Gas and Water regression. It can also be noted that the use of the reciprocal regression provides a partial solution to the problem of weak instruments in that the F-test for instrument validity now rejects the null for the Manufacturing and Services sectors.

V. Conclusions

This paper has applied Hall's (1988) methodology to investigate the possible existence of market power in UK industry. The estimates presented in this paper are consistent with Hall in that we find evidence of market power in some sectors but not in others. However, it should be emphasised that the results are conditional on the assumption of constant returns to scale. Finally, it should be noted that market power is most evident in the manufacturing and services sectors which together account for a large fraction of overall output.

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		Agriculture	Mining and Quarrying	Manufacturing	Construction	Electricity, Gas and Water	Services
Output Growth	Mean	1.85	-1.57	1.25	1.64	2.88	2.51
	SD	5.81	7.10	3.82	4.85	4.54	1.43
Employment Growth	Mean	-1.55	-3.80	-1.41	0.23	-0.39	1.30
	SD	4.28	6.68	3.05	3.48	3.69	1.60
Capital Services Growth	Mean	2.81	2.81	2.03	4.16	2.92	4.53
	SD	4.03	4.03	2.42	2.87	2.61	1.93
Solow Residual	Mean	0.90	-2.80	1.54	-0.39	1.14	-0.19
	SD	6.41	7.81	3.12	4.01	5.08	1.50
Employment Weight α		0.4269	0.2396	0.6762	0.5433	0.3603	0.5675

Table 1: Sample Statistics – Annual Percentage Changes 1952-2015

(Employment weights are 2014 shares in net output)

	Agriculture	Mining and Quarrying	Manufacturing	Construction	Electricity, Gas and Water	Services
Agriculture	1.00					
Mining and Quarrying	-0.12 <i>-0.01</i>	1.00				
Manufacturing	0.05 <i>0.04</i>	-0.09 <i>0.03</i>	1.00			
Construction	0.22 <i>0.20</i>	0.01 <i>0.13</i>	0.61 <i>0.38</i>	1.00		
Electricity, Gas and Water	-0.35 <i>-0.24</i>	0.23 <i>0.27</i>	0.14 <i>0.04</i>	0.03 <i>0.08</i>	1.00	
Services	-0.02 <i>-0.03</i>	0.07 <i>0.08</i>	0.63 <i>0.30</i>	0.55 <i>0.33</i>	0.11 <i>0.05</i>	1.00

Table 2: Correlation Matrix – Annual Percentage Changes 1952-2015

Figures in bold show correlation of output changes, figures in italics show correlation of Solow residuals.

	Slope Coefficient	Standard Error	P-value	F-statistic for instruments regression
Agriculture	0.1387	0.5329	0.7955	1.36
Mining and Quarrying	0.1298	1.1480	0.9103	0.24
Manufacturing	1.9439	0.9573	0.0467*	1.55
Construction	0.8935	0.5600	0.1157	1.60
Electricity, Gas and Water	-0.6129	0.7962	0.4451	1.00
Services	1.0317	0.5037	0.0448*	1.61

Table 3: Test for null hypothesis of a zero covariance between the Solow residual and the equation instruments (indicates significance at the 5% level). Annual data 1952-2014.*

	Intercept Estimate $\hat{\beta}_0$	Slope Estimate $\hat{\beta}_1$	Durbin-Watson Statistic	F-test for weak instruments	Implied Mark-up Ratio $\hat{\mu} = 1 + 1 / (\hat{\beta}_1 \alpha)$	Implied rate of technical progress $\hat{\theta} = -\hat{\beta}_0 \hat{\beta}_1$
Agriculture	-4.6678 (1.11)	0.3684 (0.89)	1.34	0.45	7.36	1.72
Mining and Quarrying	-1.8454 (24.80)	1.6004 (8.02)	1.22	0.02	3.61	2.95
Manufacturing	-4.2410 (0.5675)	0.4753 (0.24)	1.08	9.85	4.11	2.02
Construction	-3.4460 (0.66)	0.9273 (0.58)	1.44	1.44	2.98	3.20
Electricity, Gas and Water	-1.8269 (1.63)	-1.0582 (1.20)	1.60	0.31	-1.62	-1.93
Services	-3.0135 (0.27)	0.8400 (0.43)	1.55	3.97	3.10	2.53

Table 4: Estimates of the mark-up ratio using TSLS estimates of the reciprocal regression (Standard errors are given in parentheses below coefficient estimates)