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# Hall-Roeger Tests of Market Power in Irish Manufacturing Industries

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*Abstract*: The Hall-Roeger methodology for the testing of market power is applied to Irish manufacturing industries for the period 1991-1999. The paper adapts their methodology to permit discrimination between input and output-price-based sources of market power. The empirical results do not indicate much evidence of significant imperfect competition in output markets but the results do point to evidence of market power in certain input markets and in some industrial sectors. The implications of these findings are discussed.

## I INTRODUCTION

This paper applies a test for market power, originally proposed by Hall (1988) and subsequently modified by Roeger (1995), to Irish manufacturing industries using the *Census of Industrial Production* (CIP) database for the period 1991 to 1999.

Our interest in testing for market power in Irish manufacturing industries is motivated by two overall concerns: one macroeconomic and one microeconomic. The inability of most Irish firms to influence the prices paid for their outputs or inputs, and especially those exposed to international competition in foreign and domestic markets, has long been accepted as central to the characterisation of Ireland as the classic case of the small open economy.[1] Evidence for this view has largely been confined to aggregate level

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[1] Geary's (1974) paper is generally credited with emphasising the relevance of price-taking behaviour in an Irish context.

analyses. Browne in a number of papers (1982, 1983 and 1984) presents strong evidence that price-taking behaviour in output markets is a more than reasonable assumption. His analyses were conducted at the level of aggregate exports and hence it is always possible that his findings could obscure the presence of potential market power in some sectors of manufacturing industry. The only study, that we are aware of, that sets out to test the price-taking assumption in output markets for sub-sectors of Irish manufacturing industry has been undertaken by Callan and Fitz Gerald (1989). Their study first confirms price-taking behaviour at the level of aggregate manufacturing industry. Their tests for sub-sectors of manufacturing industry are conducted at the two-digit level and their findings strongly support price-taking behaviour at this level of aggregation. It is also possible, however, that, just like Browne's findings, the two-digit level of aggregation masks the exercise of market power at lower levels. This study adds to this empirical literature by conducting tests of market power at the four-digit manufacturing level.

The ability to conduct tests of market power at the lowest possible level of aggregation of firm groupings[2] is also highly desirable when we want to focus on the potential exercise of market power to impose excessive cost burdens on particular economic agents. In an Irish context, the establishment of the Competition Authority in 1991, and especially its acquisition of enhanced powers in 1996, has focused attention on the existence of market power and its possible abuse (see Massey and Daly, 2003). In turn, the employment of robust empirical tests of market power has assumed a practical relevance in the context of the requirement to provide a potential evidential basis for legal interventions. Thus a second motivation for this paper is to explore the evidence for the presence of market power at the four-digit manufacturing industry level which may have relevance in the context of competition policy. We also believe that the methodology that we employ in the testing of market power could have a potential evidential role in certain legal interventions.

A feature both of the macro-level studies and much of the micro-level inquiries concerning price-taking behaviour is that they are most always concerned with the potential exercise of market power in output markets. Both the buyers and sellers of inputs can of course also exercise market power. While the presence and exercise of market power in input markets is a lower order of concern in terms of potential welfare losses, it is not unimportant and thus the fact that it is an issue which is virtually ignored in empirical studies of market power is, to say the least, a curious omission.

Alan Manning (2003) has recently supplied a number of cogent reasons as to why we should be concerned about monopsony power in particular. For

[2] Ideally one would like to focus at the firm level but this is not feasible given the available data.

instance, it is a well-known result that if we assume monopsony power in labour markets, employment is predicted to increase in the wake of the introduction of, or, an increase in minimum wages. This has assumed practical relevance in an Irish context since the introduction of the minimum wage in April 2000. Apart from the labour input, the concern over monopsony power may also be relevant for other inputs. A particularly interesting case is the purchase of primary agricultural produce for further processing. In the US, farmer suppliers of tobacco are generally considered to have suffered from the abuse of monopsony power at the hands of the powerful tobacco manufacturing companies (see Raper, Love and Shumway, 2000). (Interestingly, these companies were found to also possess market power in their output markets.) This example has an interesting echo in an Irish context. Irish beef producers have periodically complained that they have been subject to abuse of market power by the Irish beef-processing sector (see Bonner, McCarthy and Sheehy, 2000).[3]

Rather than dismissing the potential of monopsony power as a theoretical curiosity, we contend that it would be much preferable to test for its presence.

Sellers of inputs can of course also exercise market power. The level of concentration among the providers of utilities like electricity and fuel, for instance, tends to be very high and the potential for excessive pricing is correspondingly high. Also the sellers of some professional services may also be capable of exercising market power. These possibilities warrant empirical testing.

Thus another motivation for our paper is to explicitly consider the evidence for both input and output price sources of market power.

The paper is laid out as follows. Section II sets out the methodology employed in testing for market power. The methodology is based on that proposed by Hall and Roeger and, as far as we are aware, ours is the first application in an Irish context. In Section III we first describe the variables used in the empirical analysis that are drawn from the Irish Central Statistics Office (CSO), *Census of Industrial Production* (CIP) four-digit level electronic database. We then present and interpret the test results and in Section IV we make some concluding remarks.

## II THE HALL-ROEGER TEST FOR MARKET POWER

While there are a number of approaches that could potentially be employed to test for the presence of market power, the Hall-Roeger approach has a

[3] Similar concerns have been expressed from time to time about the exercise of market power by the Irish sugar- processing industry.

number of relatively attractive features that commend it for our purposes.[4] For one, their approach does not require the specification of particular functional forms that can affect the results produced by the more traditional approaches. Second, their methodology is relatively parsimonious in terms of data requirements which is a most important consideration when one wants to undertake analysis of market power at the four-digit manufacturing industry level.

The Hall-Roeger methodology is set out here using Roeger's approach as we use this method in our empirical application but an essentially similar elucidation can be provided using the Hall method.

Roeger's methodology, which is derivative of Hall's, shows that, apart from a random error term that captures measurement error, the difference between the quantity and price-based Solow residuals should vanish under the null hypothesis of perfect competition in product and input markets. Thus, suppose a firm's technology can be characterised by a two-input constant-returns-to-scale production function, then

$$SR - SRP = [(\Delta y + \Delta p) - (\Delta x_1 + \Delta w_1)] - s_2^*[(\Delta x_2 + \Delta w_2) - (\Delta x_1 + \Delta w_1)] = 0 \qquad (1)$$

where,

| | |
|---|---|
| $SR$ | = quantity-based or "traditional" Solow residual, |
| $SRP$ | = price-based or "dual" Solow residual, |
| $w$'s | = input prices, |
| $p$ | = price of output, |
| $\Delta y$ | = (log) change in gross output, |
| $\Delta x$'s | = (log) change in inputs, and |
| $s_2^*$ | = cost share of input $x_2$ in the value of output. |

Suppose now we wish to test for monopoly power in the pricing of outputs. The 'true' cost share ($s_2^*$) under competitive pricing may be written

$$s_2^* = \frac{w_2 x_2}{(mc)y} = \frac{w_2 x_2}{(mc)y}\frac{p}{p} = (1 + \beta^{mp})\, s_2 \qquad (2)$$

and if $\beta^{mp} = 0$, then $s_2^* = s_2$,

[4] For example, Schroeter (1988) gives a good application of the so-called conjectural elasticities' approach to the testing of market power while Massey (2000) provides an overview of some other approaches.

where,

$mc$ = marginal cost of production,

$\beta^{mp}$ = the monopoly output-price mark up, that is, $(p\text{-}mc)/mc$,[5]

$s_2$ = the actual cost share, defined as, $w_2x_2/py$.

If product markets were, however, characterised by monopoly behaviour, then replacing $s_2$* in (1) by the expression in (2), we can obtain the following two equations for the estimation of the mark-up coefficient

$$SR - SRP = \frac{\beta^{mp}}{1 + \beta^{mp}} [(\Delta y + \Delta p) - (\Delta x_1 + \Delta w_1)] + \varepsilon \qquad (3)$$

$$SR - SRP = \beta^{mp}\ s_2[(\Delta x_2 + \Delta w_2) - (\Delta x_1 + \Delta w_1)] + \varepsilon \qquad (3)(a)$$

where,

$\varepsilon$ = random error term.

By analogy (see Raper, Love and Shumway, 2000), suppose now purchases of, for example, $x_2$ in Equation (1) were subject to market power, then the cost share term becomes $s_2(1+\beta_2^{ms})$, where $\beta_2^{ms}$ is the coefficient of input-based market power, that is, $(vmp\text{-}w_2)/w_2$, and $vmp$ is the marginal value product of $x_2$. It should be noted that this term could be either positive (implying input-buyer power, that is, monposony) or negative (implying input-seller power). Incorporating this expression for $s_2$* in (1) we obtain an econometric test given by Equation (4)

$$SR - SRP = \beta_2^{ms}\ s_2[(\Delta x_2 + \Delta w_2) - (\Delta x_1 + \Delta w_1)] + \varepsilon \qquad (4)$$

However, it is apparent that the estimation of (3)(a), or, (4) provides identical information on the extent and source of departures from perfect competition, despite 3(a) being explicitly derived from the presumption of monopoly power in output markets. It is thus impossible by using the Hall-Roeger methodology to discriminate between output-based and input-based sources of imperfect competition.[6] Thus, at best it is misleading to refer to tests such as (3) or (4) as tests of "monopoly", or, "monopsony" power, or, more

[5] This coefficient is directly related to the Lerner coefficient since, $\beta^L = \beta^{mp}/(1+\beta^{mp})$, where, $\beta^L$ is the Lerner coefficient, and for small values it will be identical.

[6] Hall seems to acknowledge as much when he suggests in his concluding comments that a possible explanation for his estimate of a relatively large and statistically significant mark-up coefficient, which is obtained by estimating an equation like (3), could be monopsony behaviour on the part of input purchasers.

precisely as exclusively output-based, or, exclusively input-based measures of market power.

We now propose a simple but useful extension of the Hall-Roeger method. Suppose we permitted (1) to be afflicted by output and input-based ($x_2$) sources of market power. Equation (2) now becomes

$$s_2{}^* = \frac{w_2 x_2}{(mc)y} = \frac{w_2 x_2}{(mc)y} \frac{p}{p} \frac{vmp}{w_2} = (1 + \beta^{mp})(1 + \beta_2{}^{ms})\, s_2 \qquad (5)$$

where,

$vmp$ = marginal value product of $x_2$.

Substituting (5) for $s_2{}^*$ in (1) we obtain an expression of the following general form that allows for firms to exercise potential market power in both output and input M-1 markets

$$SR - SRP = \sum_{j=2}^{j=M} (\beta^{mp} + \beta_j{}^{ms} + \beta_j{}^{ms}\,\beta^{mp})$$
$$s_j\,[(\Delta x_j + \Delta w_j) - (\Delta x_1 + \Delta w_1)] + \varepsilon \qquad (6)$$

or, writing (6) using simpler notation

$$v = \sum_{j=2}^{j=M} \phi_j z_j + \varepsilon \qquad (7)$$

where,

$$v = SR - SRP$$
$$\phi_j = \beta^{mp} + \beta_j{}^{ms} + \beta_j{}^{ms}\,\beta^{mp} \text{ and}$$
$$z_j = s_j\,[(\Delta x_j + \Delta w_j) - (\Delta x_1 + \Delta w_1)]$$

Suppose we obtain statistically significant estimates of the $\phi_j$s from an estimation of Equation (7). This would suggest the presence of market power on the part of buyers and/or sellers. However, inspection of Equation (6) implies that the non-rejection of equality of the $\phi_j$s in (7) would strongly suggest market power in the setting of output prices.[7] On the other hand, rejection of equality of the $\phi_j$s would provide strong support for imperfect competition in the pricing of inputs. The qualification attaching to the latter

[7] Inspection of Equation (6) reveals that we are excluding here the possibility that the $\beta_j{}^{ms}$ are all of an equal non-zero magnitude which seems highly improbable.

interpretation is that rejection of equality of the market-power coefficients could also be consistent with imperfection competition in the pricing of *both* input and output prices. If monopoly power were in reality present, the coefficient estimates from (7) would thus be upper-bound estimates of the extent of market power in the pricing of inputs. By forcing equality of the $\phi_j$s in (7), which would be equivalent to the estimation of Equation 3(a), we obtain upper-bound estimates of the monopoly (output-based) power coefficients. If these values were close to zero, and bearing in mind that they are upper-bound estimates, it is apparent from Equation (6) that statistically significant $\phi_j$s could be interpreted as unambiguously arising from imperfect competition in the pricing of inputs.

As previously noted, departures from perfect competition in input pricing could occur either because firms can exercise monopsony power in the purchase of inputs or because the sellers of inputs can exercise market power. Thus, to reiterate, it is possible for the $\phi_j$s to be positively signed (input-buyer power) or negatively signed (input-seller power).

## III AN EMPIRICAL APPLICATION TO IRISH MANUFACTURING INDUSTRIES

### *3.1 Data*

The electronic version of the *Irish Census of Production* (CIP) database, as published by the Central Statistics Office (CSO), is employed to test for the presence of potential market power in Irish manufacturing industry industries. For each year, the full dataset provides information on 138 four-digit industrial sectors.

An attractive feature of the Roeger version of the test which we use is that the basic data required are denominated as the log changes in the value of outputs and inputs. Therefore, one does not need to employ separate estimates of prices and quantities to implement the test. This is especially attractive in the case of capital, where it is notoriously difficult to generate stock data, especially at the four-digit level.

From the CIP, data are available on the nominal value of each sector's gross output together with each sector's expenditure on "Materials", "Services", "Fuel and Power", "Industrial Employment" and "Other Employment". Under the assumption of constant returns to scale, capital costs are implicitly given as "the remainder of net output". At the commencement of this study we had access to nine years of such data from 1991 to 1999.

The dataset allowed us to form a panel. In forming the panel we had to ensure that the same four-digit sector aggregates were available each year.

Since it would appear plausible that the presence of market power could be related to certain structural features of manufacturing industries, such as, the ownership status (foreign versus indigenous), we felt it was important to generate separate coefficients for each broad manufacturing sector (that is, the two-digit level).[8] We confined the analysis to those broad manufacturing sectors for which we had a sufficient number of observations to conduct a separate regression analysis for each sector. These considerations resulted in 109 four-digit level observations across 17 broad manufacturing sectors being available for each year. As we lose one year's data due to the regression variables being defined in terms of log changes, the total number of observations in the panel is 8 × 109 = 872 for the period 1992 to 1999.

*3.2 Regression Analysis and Results*

We exploit the panel nature of our data to test for possible differences in the market-power coefficients between broad manufacturing sectors by estimating a "fixed-effects" version of Equation (7)[9]

$$v_{ikt} = \sum_{j=2}^{j=M} \phi_{j1}\, z_{ij1t} + \sum_{k=2}^{k=L} \sum_{j=2}^{j=M} \gamma_{jk}\, z_{ijkt}\, D_k + \varepsilon_{ikt} \tag{8}$$

where, i=1,…, N denotes the four-digit level observation; k=1,…, L denotes the broad manufacturing sector (two-digit level); t=1,…, 8 denotes the years; the $\gamma s$ have the usual interpretation as the difference between the market-power coefficient value for a single broad manufacturing sector (k=1) and each of the remaining two-digit sectors (k=2,…,L) and D is a dummy variable that takes a value of 1 if the observation falls into the $k^{th}$ sector (k=2,…,L) and zero otherwise; and $j$=1 is defined as the capital input and j=2,…, M denotes the remaining production inputs, "Materials"(2), "Services"(3), "Fuel and Power"(4), "Industrial Employment"(5) and "Other Employment"(6).

Thus we assume constant market-power coefficients *within* each broad industrial sector and over the time period of the study but we allow the coefficients to differ *between* each broad manufacturing sector. Hence the variation in the data that enable us to estimate the coefficients involves a

[8] It would be interesting to be able to discriminate between four-digit sectors on the basis of ownership status but the available data only allows us to discriminate on this basis at the two-digit level.

[9] This estimation approach is equivalent to running separate regressions for each two-digit manufacturing sector.

combination of cross-sectional and time-series variation across the four-digit observations *within* each broad industrial sector.[10]

The market-power coefficients for each broad manufacturing sector are thus generated as

$$\phi_{jk} = \phi_{j1} + \gamma_{jk}; \; k = 2, ..., M \tag{9}$$

with associated standard errors.

Estimation of Equation (8) using OLS (with White-adjusted standard errors) yielded the results given in Table 1. The $\bar{R}^2$ value was 0.56 and the LM-autocorrelation value was 0.14 with a standard error of 0.09.[11] Our results thus imply the presence of market power given the Hall-Roeger interpretation of our estimated equation.

A likelihood-ratio test for equality of the market-power coefficients (the $\phi_{jk}$s), within each broad manufacturing sector, produced a value of 366 with 17 degrees of freedom which substantially exceeds the critical $\chi^2$ value. Thus we strongly reject the null hypothesis of equality of the market-power coefficients *within* each broad manufacturing sector which rejects the possibility that the source of market power is likely to be due to monopoly pricing of outputs. In Appendix 1 we present estimates of the Hall-Roeger output-based monopoly-power coefficients that are obtained by restricting the input market-power coefficients to be equal. It is apparent that there is little evidence of monopoly power in the setting of output prices. This finding, together with rejection of equality of the input-based market-power coefficients *within* the manufacturing sectors, provides support for the hypothesis that the source of market power lies in imperfect competition in the pricing of inputs. A likelihood-ratio test also strongly rejected the hypothesis that there was no significant difference in the market-power coefficients *between* manufacturing sectors[12].

[10]Both Hall (1988) and Roeger (1995) conduct their regression analyses for US manufacturing by exploiting time- series variation at the two-digit level for the period 1953-1984. Our study has the advantage of being undertaken at the four-digit level but we need to exploit both cross-sectional and time-series variation to generate sufficient observations for estimation. While Hall and Roeger use a longer time-period than ours, the reasonableness of the implied assumption of constant market-power coefficients over such a long time period can be questioned.

[11] The Lagrange Multiplier test for first-order autocorrelation was obtained by regressing the residuals from Equation (8) on their lagged values and the other right-hand-side variables. We also estimated Equation (8) using a first-order autocorrelation-corrected estimator and the resulting autocorrelation coefficient was also not statistically different from zero.

[12] We also carried out a number of robustness checks of our findings. These involved running the regressions for a dataset that omitted "influential" observations and using the Least Absolute Difference estimator. While both of these estimation approaches led to a reduction in the magnitude of the coefficients of market power, we still strongly rejected the null hypothesis of equality of the coefficients for each input *within* and *between* broad manufacturing sectors.

We now turn to the coefficient estimates themselves which we interpret as indicating the presence of market power in the pricing of inputs. Under this interpretation, the $\phi_{jk}$s equal the difference between the implied marginal value product of the inputs and their corresponding prices expressed as a ratio of actual input prices. For ease of interpretation we multiply these coefficient estimates by 100 giving us the percentage difference between the value of the marginal products and input prices. These adjusted estimates are presented in Table 1.

We find a preponderance of significant market-power coefficient estimates for the "Materials" (13 sectors) and "Services" (11 sectors) inputs. About seven sectors report statistically significant values for "Industrial Employment" with five and four sectors respectively returning statistically significant values for "Other Employment" and "Fuel and Power".

As to the magnitude of the coefficients, we find that about eight sectors report a market-power coefficient for "Materials" that is greater than or equal to 0.5 per cent. Interestingly, while we do find statistically significant evidence of market power in the purchase of materials for the food industry, the magnitude of the market-power coefficient is relatively low at about 0.6 per cent.

The finding of a negative and large market-power coefficient for "Services" for several sectors is interesting. The result implies that the sectors in question are paying substantially more for these inputs than their internal marginal value to the industries concerned. About seven sectors report a market-power coefficient for "Services" that is greater than or equal to –5 per cent. Around eight sectors return an estimated market-power coefficient in respect of "Industrial Employment" that exceeds or equals 1 per cent.

Three sectors stand out as having especially large and statistically significant market-power coefficients in respect of "Materials", "Services" and "Industrial Employment", namely, "Textiles", "Chemicals" and "Fabricated Metals". As far as the labour input is concerned, "Textiles" stands out as possibly being afflicted by monopsonistic-type conditions in that the market power coefficient is found to be 10 per cent for "Other Employment" and over 3 per cent for "Industrial Employment".

Our estimates indicate a much lower order of market power than those produced by Roeger for the US, who in turn obtained substantially lower estimates than Hall. This is not unexpected given the presumption that the Irish case corresponds closely to the small-open-economy paradigm. Nonetheless, the contrasting estimate magnitudes are noteworthy. Roeger reports the percentage difference between price and marginal cost, expressed relative to marginal cost, ranging from 15 per cent for the textile sector to 214 per cent for public utilities (electricity, gas and sanitary services).

Table 1: *Market-Power Coefficient Estimates (%) for Irish Manufacturing Industries, 1991-1999 (standard errors in parentheses)*

| *Broad Manufacturing Sector (Obs.=NxT)*[a] | $\phi_2$ *Materials* | $\phi_3$ *Services* | $\phi_4$ *Fuel and Power* | $\phi_5$ *Other Employ-ment* | $\phi_6$ *Industrial Employ-ment* |
|---|---|---|---|---|---|
| Food | 0.60 | –4.70 | –6.10 | 1.40 | 1.50 |
| (104) | (0.20)** | (2.30)** | (2.90)** | (1.70) | (1.10) |
| Textiles | 1.00 | –19.20 | –12.10 | 10.00 | 3.40 |
| (72) | (0.50)** | (6.70)** | (5.10)** | (4.10)** | (1.90)* |
| Wearing Apparel | 1.50 | –3.60 | 2.20 | 1.30 | –0.30 |
| (32) | (0.80)* | (2.80) | (5.80) | (5.00) | (1.70) |
| Wood & Wood Prods. | 0.20 | –7.00 | –1.40 | 1.40 | 1.50 |
| (32) | (0.10)* | (1.80)** | (2.00) | (1.10) | (0.70)** |
| Pulp & Paper | 0.50 | –0.30 | –2.80 | –2.80 | 0.80 |
| (32) | (0.10)** | (1.4) | (1.90)* | (1.20)** | (0.40)** |
| Printing & Rec. Media | –0.10 | –1.00 | 3.20 | –0.70 | 0.20 |
| (40) | (0.10) | (1.00) | (3.30) | (0.40)* | (0.30) |
| Chemicals | 1.60 | –12.60 | –4.20 | –3.60 | 0.40 |
| (88) | (0.60)** | (6.20)** | (4.10) | (2.60) | (4.80) |
| Rubber & Plastic | 0.15 | –0.60 | –0.06 | –0.30 | 0.60 |
| (40) | (0.00)** | (0.40) | (1.00) | (0.40) | (0.50) |
| Other Non-Metallic | 0.60 | –13.20 | –1.90 | –2.30 | 1.60 |
| (72) | (0.20)** | (1.60)** | (0.80)** | (0.70)** | (0.60)** |
| Fabricated Metals | 0.10 | –13.90 | –9.50 | 4.70 | 5.30 |
| (96) | (0.30) | (4.00)** | (10.20) | (3.00) | (3.30)* |
| Machinery & Equipment | 0.30 | –3.60 | –1.30 | 0.30 | 0.40 |
| (80) | (0.10)** | (0.90)** | (1.80) | (0.50) | (0.20)** |
| Electrical Machinery | 0.30 | –4.80 | 3.10 | 1.90 | –0.20 |
| (48) | (0.20)* | (2.40)** | (4.20) | (1.80) | (0.50) |
| Radio, TV & Comm. Equip. | 0.60 | –7.60 | 11.80 | 0.50 | –0.80 |
| (24) | (0.10)** | (2.80)** | (11.90) | (1.10) | (0.90) |
| Med., Prec. & Opt. Instrum. | –0.30 | –18.80 | –5.60 | 2.00 | 0.70 |
| (24) | (0.20)* | (2.70)** | (4.20) | (1.40)* | (0.80) |
| Motor Vehicles | –0.04 | –3.90 | –3.40 | –0.14 | 2.00 |
| (24) | (0.10) | (1.30)** | (2.90) | (2.00) | (0.20)** |
| Other Trans. Equip. | –1.20 | –0.80 | 29.10 | –12.90 | 5.10 |
| (24) | (2.40) | (6.60) | (30.60) | (9.00) | (3.30)* |
| Furniture | 1.50 | 2.80 | 3.60 | 3.40 | 2.30 |
| (40) | (0.80)** | (6.40) | (15.20) | (5.40) | (3.70) |

a: Since the coefficients reported here are based on the estimation of a "fixed-effects" model, the relevant number of observations for the regression analysis is N × T = 872 with 787 degrees of freedom.

$\phi_2$ = materials; $\phi_3$ = services; $\phi_4$ = fuel and power; $\phi_5$ = "other" employment; $\phi_6$ = industrial employment.

*: denotes statistically significant at the 90 per cent confidence level.

**: denotes statistically significant at the 95 per cent confidence level.

## IV CONCLUDING REMARKS

This paper has applied Roeger's version of Hall's non-parametric test of market power to Irish manufacturing four-digit industries. The paper demonstrates the equivalence of output-based and input-based versions of the test and suggests that tests of "market power" is a more neutral and acceptable term. The paper also proposes a simple test that is capable of discriminating between imperfect competition in the pricing of outputs and inputs.

A number of the findings are worth noting. We find evidence of statistically significant market power in the pricing of a number of production inputs. We strongly reject the hypothesis that the market-power coefficients are similar across two-digit industrial sectors. Our results also suggest that the source of market power is most likely due to the pricing of inputs rather than outputs. This finding, at the four-digit manufacturing sector, confirms the strong prior of price-taking behaviour in output markets that has been found in several previous Irish studies using more aggregated data.

While we find statistical support for the presence of market power in the pricing of inputs in many sectors, the sectors where the exercise of market power appears to be most prevalent are: "Food", "Textiles", "Wood and Wood Products", "Pulp and Paper", "Other non-Metallic" and "Medical Precision and Optical Instruments". With the exception perhaps of the "Other non-Metallic" sector, there is no obvious pattern that can be discerned here in terms of export orientation or ownership status (foreign versus indigenous).

The economic importance of the finding of market power in input pricing that we find for many sectors has to be tempered by the relatively small magnitude of the coefficients in most cases. However, there are a number of coefficients that would appear to be of *prima facie* importance. For instance, the finding that the market-power coefficient for "Other Employment" is about 10 per cent in the "Textiles" sector implies a labour supply elasticity to the sector of about 10. While most of the estimates imply an elasticity which is much higher than this, these are still at odds with the assumption of an infinitely elastic labour supply which is implied by the competitive model. This finding could have implications for the impact of minimum wages in this sector. It is also worth noting that the sectors where we find evidence of relatively sizeable buyer power in regard to labour inputs tend to be also the relatively most intensive users of labour. For instance, for the last year of our analysis, the share of "Wages and Salaries" in total output was over 24 per cent for "Textiles" and in excess of 30 per cent for "Other Transport Equipment".

In many respects the most surprising result is the statistically significant and relatively large negative market-power coefficient that is obtained for "Services"[13] for several sectors. This input comprises activities that firms must acquire on a consulting basis (e.g. accounting and legal services, etc.). The implication here is that these inputs are priced significantly above their marginal value to the sectors concerned. Indeed, in some cases, the price of "Services" appears to be substantially ahead of its internal value to firms. This is a finding that would appear to merit much further study because it could indicate an uncompetitive structure in the supply of "Services" to firms.[14]

In conclusion, it is important that attention is drawn to the *caveats* that attend to the methodology employed in this paper. Both Hall and Roeger acknowledge a number of alternative explanations to the presence of market power that could explain the finding of a statistically significant gap between the primal and dual versions of the Solow residual. The methodology assumes a constant-returns-to-scale technology and it is incapable of distinguishing between a market-power and an increasing-returns effect. It is difficult to have strong priors about what sectors might be expected to exhibit increasing returns at the four-digit level of aggregation but, on the face of it, none of the sectors for which we obtain sizeable coefficient values would appear to fall into this category. Another possible explanation for the results is that both the suppliers and buyers of inputs may enjoy relatively different bargaining strengths at different points of the economic cycle and hence the gap between marginal value products and actual input prices may arise because of adjustment lags. This would be an interesting idea for further research because it suggests that the estimates of market power may vary over time and this hypothesis could be tested given the availability of more time series observations.

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[13] The coefficient for "Other Employment" is also negative but it is statistically much less significant than "Services", "Materials" or "Industrial Employment".

[14] Since this paper was written the Competition Authority has commissioned a series of studies on the supply of professional services. The main study by Indecon (2003) is available from the Authority's website.

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Appendix 1: *Market-Power Coefficient Estimates[a] (%) for Irish Manufacturing Industries, 1991-1999 Assuming that Only Monopoly Power is Present (standard errors in parentheses)*

| *Broad Manufacturing Sector (Obs.=NxT)* | |
|---|---|
| Food | 0.40 |
| (104) | (0.08)** |
| Textiles | 1.46 |
| (72) | (0.45)** |
| Wearing Apparel | 0.66 |
| (32) | (0.18)** |
| Wood & Wood Prods. | 0.19 |
| (32) | (0.08)** |
| Pulp & Paper | 0.25 |
| (32) | (0.06)** |
| Printing & Rec. Media | –0.15 |
| (40) | (0.10) |
| Chemicals | 0.50 |
| (88) | (0.58) |
| Rubber & Plastic | 0.16 |
| (40) | (0.04)** |
| Other Non-Metallic | –0.50 |
| (72) | (0.40) |
| Fabricated Metals | 0.90 |
| (96) | (0.46)** |
| Machinery & Equipment | 0.17 |
| (80) | (0.05)** |
| Electrical Machinery | 0.26 |
| (48) | (0.08)** |
| Radio, TV & Comm. Equip. | 0.50 |
| (24) | (0.06)** |
| Med., Prec. & Opt. Instrum. | –0.21 |
| (24) | (0.17) |
| Motor Vehicles | 0.47 |
| (24) | (0.09)** |
| Other Trans. Equip. | 0.30 |
| (24) | (0.93) |
| Furniture | 1.80 |
| (40) | (0.15)** |

a: These estimates are obtained from the estimation of Equation 3(a).
**: Denotes statistically significant at the 95 per cent confidence level.