TESTS OF MARKET POWER IN IRISH MANUFACTURING INDUSTRIES

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ABSTRACT

It's been a long-standing assumption that Irish manufacturing firms are price takers in their output markets. This assumption has been validated by several aggregate level studies. While a much smaller number of studies have examined this issue at a more disaggregated level, they tend to support this conclusion. All of these studies also assume that firms are price takers in their input markets, or, in other words inputs are perfectly elastically supplied to firms. This assumption, however, has never been formally tested. There is intrinsic interest in the context of competition law in ascertaining evidence of deviations from perfect competition in sales of product and purchases of inputs. Moreover the introduction of minimum wages provides an important additional motivation for the topic of this paper, since it is well known that the introduction of minimum wages or increases in the level of minimum wages can lead to increases in employment over a certain range of wages if the firm possesses market power in its labour market. By using four-digit level Census of Industrial Production (CIP) panel data the paper sets out to test the extent of potential market power in Irish manufacturing industries. The paper employs the ingenious method proposed by Hall and later modified by Roeger in this exercise. While the Hall-Roeger method was originally concerned with imperfect competition in output markets, it can be readily extended to input markets. 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.

KEY WORDS: market power, imperfect competition, minimum wages, anti-trust legislation, econometric tests.

JEL CODES: D21, D43, J42,l4, l60.

TESTS OF MARKET POWER IN IRISH MANUFACTURING INDUSTRIES[1]

1. 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. Both Hall and Roeger were interested in monopoly power but their approach can be easily extended to the case of monopsony power as demonstrated in an interesting application to the US tobacco industry by Raper, Love and Shumway (1998). Apart from the intrinsic interest in the context of competition law in ascertaining evidence of deviations from perfect competition in sales of product and purchases of inputs, the introduction of minimum wages provides an important additional motivation for the topic of this paper. It is well known that the sectoral employment response to the introduction of a minimum wage will not be negative and may well be positive if the sector is characteristic by monopsonistic-type behaviour in the labour market (see for example, Boyle, McCarthy and O'Neill (1998)).

A succession of papers have demonstrated convincingly that price-taking behaviour is a reasonable assumption as far as output markets are concerned for the Irish manufacturing sector as a whole. A smaller number of papers have verified the validity of this assumption for particular sectors of manufacturing industry (see, for example, Callan and FitzGerald (1998)). To the best of our knowledge no paper, however, has looked at whether firms are price takers in their input markets. A further aim of this paper is to attempt to fill this gap.

The paper is organised as follows. Section 2 outlines the test procedure while Section 3 discusses the database employed in the empirical analysis and presents a number of econometric tests for the presence of imperfect competition in output and input markets. Section 4 concludes the paper.

[1] I would like to thank Denis Conniffee, Donal O'Neill and Maurice Roche, together with colleagues at a departmental seminar, for comments on an earlier draft.

2. Tests of Market Power – the Hall and Roeger Approach

Hall (1988) sets out a new test for monopoly power in U.S. industry. He rejects the traditional conjectural variations' approach[2] to testing for market power, as being overly dependent in its execution on specific functional form assumptions, in favour of a non-structural reduced-form approach. His basic but powerful insight is that the traditional Solow residual (SR) should be independent of variations in the log-change of output in the absence of monopoly power.

Suppose we have a constant-returns two-input production function. Equation (1) interprets the traditional Solow residual as the sum of (unobservable) productivity shocks (ΔA) and Hicks-neutral technical change ($\Delta\gamma$).

$$SR = (\Delta y - \Delta x_1) - s_2^*(\Delta x_2 - \Delta x_1) = \Delta A + \Delta\gamma \qquad (1)$$

where,

Δy = (log) gross output,

Δx's = (log) inputs,

s_2^* = cost share of input x_2 in the value of output,

ΔA = (log) productivity shock,

$\Delta\gamma$ = (log) Hicks-neutral technical change.

To illustrate how the Hall test for monopoly power works we first define the Lerner coefficient (β^{mp}) of monopoly power as

$$\frac{p - mc}{mc} = \beta^{mp} \qquad (2)$$

where,

p = output price

mc = marginal production cost

The ‘true’ cost share (s_2^*) under competitive pricing may be written

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

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

Substituting this expression for s_2^* in (1) we can obtain two equivalent interpretations[3] of the Solow residual. First we have

$$SR = (\Delta y - \Delta x_1) - s_2(\Delta x_2 - \Delta x_1) = \frac{\beta^{mp}}{1+\beta^{mp}}(\Delta y - \Delta x_1) + \frac{\Delta A + \Delta\gamma}{1+\beta^{mp}} \qquad (3)$$

and secondly we get

$$SR = (\Delta y - \Delta x_1) - s_2(\Delta x_2 - \Delta x_1) = \beta^{mp} s_2(\Delta x_2 - \Delta x_1) + \Delta A + \Delta\gamma \qquad (3)(a)$$

The addition of an error term to equations (3) and (3)(a), which also incorporates the unobservable productivity variable ΔA, allows the Lerner coefficient β^{mp} to be estimated using econometric methods.

Raper, Love and Shumway (1998) demonstrate that Hall’s approach can easily be extended to the monopsony case. In the case of monopsony, the Lerner coefficient becomes

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[2] For a relatively recent application in this genre see Schroeter (1988) and for an overview of some other approaches to testing for market power see, for example, Massey (2000)

[3] I would like to thank Denis Conniffe for drawing my attention to this point which is not made by Hall or indeed, to the best of my knowledge, by any other author in the relevant literature.

$$\frac{vmp - w}{w} = \beta^{ms} \tag{4}$$

If purchases of say x_2 in equation (1) were subject to monopsonistic power then the cost share term becomes $s_2(1+\beta^{ms})$. Incorporating this expression for s_2^* in (1) provides the following equation for the Solow residual

$$SR = (\Delta y - \Delta x_1) - s_2(\Delta x_2 - \Delta x_1) = \beta^{ms} s_2(\Delta x_2 - \Delta x_1) + \Delta A + \Delta \gamma \tag{5}$$

Again the addition of an error term to (5) that incorporates the unobservable productivity variable, allows β^{ms} to be estimated using regression analysis.

An important implication of (5) is that it is seen to be identical to (3)(a). Thus for the two-input case it is clear that it is impossible by using Hall's methodology to discriminate between monopolistic and monopsonistic sources of imperfect competition. Hall acknowledges as much when he suggests that a possible explanation for his estimate of a relatively large and statistically significant Lerner coefficient, that is obtained by estimating an equation like (3), could be monopsonistic-type behaviour. Thus at best it is misleading to refer to tests such as (3) or (5) as tests of "monopoly" or "monopsony" power.

A more general specification would be to allow for both monopoly and monopsony sources of market power and to test for either or both sources using appropriate restrictions. Suppose then that we permitted (1) to be afflicted by both monopoly and monopsony. With this more general specification equation (2)(a) becomes

$$s_2^* = \frac{w_2 x_2}{(mc)y} = \frac{w_2 x_2}{(mc)y}\frac{p}{p}\frac{vmp}{w_2}\frac{w_2}{w_2} = (1+\beta^{mp})(1+\beta^{ms})s_2 \tag{6}$$

Substituting (6) for s_2^* in (1) we could obtain expressions that are identical to equations (3) and (5) except that the coefficient to be estimated is the product of the monopoly and monopsony Lerner coefficients. A third formulation can also be easily derived as

$$SR = \frac{\beta^{mp}}{1+\beta^{mp}}(\Delta y - \Delta x_1) + \beta^{ms} s_2 (\Delta x_2 - \Delta x_1) + \frac{\Delta A + \Delta \gamma}{1+\beta^{mp}} \tag{7}$$

At first glance, it would appear possible to use (7) to simultaneously test for imperfect competition in both output and input prices. However, on closer inspection the right-hand-side variables are seen to be nearly perfectly collinear.

Hall acknowledges that the econometric estimation of equations (3), (5) or indeed (7) is problematic because of the inherent correlation between the right-hand-side variable and the error term which it will be recalled includes *inter alia* the term, ΔA. In principle instrumental variable estimation can be employed but it will be difficult to obtain suitable instruments with the desirable statistical properties.

Roeger's (1995) contribution stems from this concern with Hall's otherwise ingenious method.

Roeger first of all points out that the Solow residual can be equivalently obtained from the cost function which is of course the dual of the production function. Denoting the residual in this instance by SRP, its value is given by

$$SRP = -(\Delta p - \Delta w_1) + s_2^*(\Delta w_2 - \Delta w_1) = \Delta A + \Delta \gamma \tag{8}$$

Roeger's basic contribution is to note 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 we have

$$SR - SRP = [(\Delta y + \Delta p) - (\Delta x_1 + \Delta w_1)] - s_2^*[(\Delta x_2 + \Delta w_2) - (\Delta x_1 + \Delta w_1)] = 0 \tag{9}$$

If product markets were, however, characterised by monopoly behaviour then replacing s_2^* in (9) by the expression in (2)(a), the following equation provides an econometric test[4]

$$SR - SRP = \frac{\beta^{mp}}{1+\beta^{mp}}[(\Delta y + \Delta p) - (\Delta x_1 + \Delta w_1)] + \varepsilon \qquad (10)$$

where,

ε = random error term.

The great advantage of Roeger's approach is of course that since ε can be interpreted to only capture measurement error there is no reason to suppose that the right-hand-side variable will be correlated with it, implying the OLS will yield a consistent estimate of . β^{mp}.

Similarly, if monopsony behaviour applies to purchases of, for instance, input x_2, then an econometric test for its presence is given by equation (11)

$$SR - SRP = \beta^{ms} s_2[(\Delta x_2 + \Delta w_2) - (\Delta x_1 + \Delta w_1)] + \varepsilon \qquad (11)$$

A further practical advantage and attractive feature of Roeger's approach worth noting is that expenditure data are typically more readily available than quantity information, especially in regard to capital stock data.

However, our observations on the Hall method concerning the difficulty of discriminating between monopolistic and monopsonistic sources of imperfect competition apply equally to Roeger's method. Thus estimation of (10) or (11) will provide essentially the same information on the extent of departures from perfect competition. Estimation of equations of the form of (11), however, provide us with a somewhat non-rigorous, if less than comprehensive, means of discriminating between monopolistic and monopsonistic sources of imperfect competition. If we allow for a firm to exercise potential market power in both output and in up to M-1 input markets, we substitute an expression of the form (6) in (9) to yield

[4] This is the dual counterpart to equation (3). We can also derive an expression similar to equation 3(a).

$$SR - SRP = \sum_{j=2}^{M} (\beta^{mp} + \beta_j^{ms} + \beta_j^{ms}\beta^{mp}) s_j [(\Delta x_j + \Delta w_j) - (\Delta x_1 + \Delta w_1)] + \varepsilon \qquad (12)$$

or, writing (12) using simpler notation

$$y = \sum_{j=2}^{M} \phi_j z_j + \varepsilon \qquad (13)$$

where,

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

The equation in (13) implies that the non-rejection of a test for equality of the ϕ_js would strongly suggest market power in the setting of output prices whereas rejection of equality of the ϕ_js would provide reasonably strong support for a monopsony basis for departures from imperfect competition. The test is of course predicated on the presumption that equality of the monopsony-based Lerner coefficients for all M-1 inputs is a highly unlikely prospect.

3. Applying Roeger’s Method to Irish Census of Production Data

3.1 Data

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 the majority of manufacturing industry sectors. For each year the full dataset provides information on some 138 four-digit industrial sectors. For each year 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 CRS, 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. As we also wanted to generate separate sets of market-power coefficient estimates at the two-digit level, we also confined the analysis to those two-digit sectors for which we had a sufficient panel of data points to conduct a separate regression analysis for each two-digit sector. These considerations resulted in 109 four-digit level observations across 17 two-digit 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 8x109= 872 for the period 1992 to 1999.

In Table 1 we furnish the list of two-digit sectors for which market-power coefficients were estimated together with selected characteristics of these sectors. Our chosen sectors account for nearly 84% of both total manufacturing employment and "Wages and Salaries" expenses. The "Food" sector (code 15) stands out as the single-largest industrial sector in our analysis. It is seen to account for nearly 20% of total manufacturing employment and "Wages and Salaries" and around a quarter of total "Materials" and "Services" expenses. Sector 24 ("Chemicals") also stands out as a sector of significance. It is clearly a capital-intensive sector and accounts for nearly 40% of "Capital" expenses for all manufacturing industries. For about six[5] of these sectors at least half of the gross output is produced by foreign-owned firms and over half[6] of the sectors export at least 60% of the output that is produced.

[5] Sectors 17-18, 22, 24, 31-33 and 34-35.
[6] Sectors 15, 17-18, 22, 24, 25, 28, 31-33, 34-35 and 36-37.

Table 1

Characteristics of the sectors employed in the estimation of the Lerner coefficients for Irish manufacturing industries (1999)

Sectors	**Manufact. Employ.**	**Wages and Salaries Expenses**	**Materials Expenses**	**Service Expenses**	**Fuel and Power Expenses**	**"Capital"[a] Expenses**
	Per cent of total manufacturing					
15 Food	18.71	18.25	23.85	17.51	27.29	14.50
17 Textiles	2.40	1.82	0.71	0.61	1.64	0.27
18 Wearing Apparel	2.27	1.53	0.55	0.72	0.79	0.33
20 Wood & Wood Prods.	2.27	1.82	1.22	1.64	3.57	0.46
21 Pulp & Paper	1.91	2.12	1.00	1.15	1.78	0.60
22 Printing & Rec. Media	7.79	9.10	3.24	7.12	2.78	16.65
24 Chemicals	9.23	11.86	10.62	18.44	15.91	39.05
25 Rubber & Plastic	4.24	3.72	1.83	2.46	4.05	0.82
26 Other Non-Metallic	4.20	4.59	1.54	4.89	10.25	1.29
28 Fabricated Metals	5.24	4.65	2.03	3.71	2.89	0.84
29 Machinery & Equipment	5.82	5.37	2.44	2.05	2.76	1.26
31 Electrical Machinery	5.85	5.23	2.71	6.64	2.18	1.44
32 Radio, TV & Comm. Equip.	5.36	5.85	7.15	10.85	5.93	6.87
33 Med., Prec. & Opt. Instrum.	6.27	5.24	2.65	1.34	2.70	2.37
34 Motor Vehicles	1.65	1.47	0.99	0.73	0.70	0.22
35 Other Trans. Equip.	2.20	2.73	0.66	3.86	1.03	0.32
36 Furniture	4.32	3.62	2.91	1.65	2.30	1.05
All (%)→	**83.46**	**83.73**	**63.45**	**84.03**	**85.85**	**85.97**

a: "Remainder of net output".
Source: Derived from the Census of Industrial Production (1999), Irish Central Statistics Office

In Table 2 we document the output shares of the major expense items for each of the two-digit sectors. With the exception of sector 24("Chemicals") by far the dominant expense item is "Materials" followed by "Capital" then "Wages and Salaries".

Table 2
Output shares(%) of the major expense items of the sectors employed in the estimation of the Market-Power coefficients for Irish manufacturing industries (1999)

Sector	"Materials"	"Services"	"Fuel and Power"	"Wages and Salaries"	"Capital"[a]	Total
15 Food	51.6	1.4	1.2	7.6	38.1	100.0
17 Textiles	49.1	1.6	2.4	24.2	22.8	100.0
18 Wearing Apparel	42.5	2.1	1.3	22.8	31.3	100.0
20 Wood & Wood Prods.	53.8	2.7	3.3	15.5	24.7	100.0
21 Pulp & Paper	45.2	1.9	1.7	18.5	32.7	100.0
22 Printing & Rec. Media	12.7	1.0	0.2	6.8	79.2	100.0
24 Chemicals	17.3	1.1	0.5	3.7	77.3	100.0
25 Rubber & Plastic	49.2	2.5	2.3	19.3	26.8	100.0
26 Other Non-Metallic	35.1	4.1	4.9	20.2	35.7	100.0
28 Fabricated Metals	49.0	3.3	1.5	21.7	24.6	100.0
29 Machinery & Equipment	47.5	1.5	1.1	20.1	29.8	100.0
31 Electrical Machinery	47.2	4.3	0.8	17.5	30.3	100.0
32 Radio, TV & Comm. Equip.	41.7	2.3	0.7	6.6	48.7	100.0
33 Med., Prec. & Opt. Instrum.	36.6	18.6	9.3	18.9	16.6	100.0
34 Motor Vehicles	62.6	1.7	0.9	18.0	16.7	100.0
35 Other Trans. Equip.	37.8	8.2	1.2	30.4	22.3	100.0
36 Furniture	58.3	1.22	1.0	14.0	25.5	100.0

a: "Remainder of net output".
Source: Derived from the Census of Industrial Production (1999), Irish Central Statistics Office

3.2 Regression analysis and results

Our basic regression equation is

$$y = \sum_{j=2}^{M} \phi_j \; z_j + \varepsilon \tag{14}$$

We also exploit the panel nature of the data to test for differences in the market-power coefficients across our 17 two-digit sectors by estimating an equation of the form

$$y = (\sum_{j=2}^{M} \phi_j \; z_j)_N + \sum_{i=1}^{N-1} \sum_{j=2}^{M} \gamma_{ij} z_j D_i + \varepsilon \tag{15}$$

where, γ has the usual interpretation as the difference between the market-power coefficient value for the nth two-digit sector and the ith two-digit sector and D is a dummy variable that takes a value of 1 if the observation falls into the ith two-digit sector and zero otherwise.

The market-power coefficients for each two-digit sector are thus generated as

$$\phi_{ij} = \phi_j + \gamma_{ij} \tag{15)(a}$$

with associated standard errors.

3.2.1 Results assuming constant slopes across the two-digit sectors

Estimation of equation (14) using OLS yielded the results given in Table 3. We report an $\overline{R}^2$ of 0.37, which is a reasonable fit for these kind of data and a statistically insignificant first-order autocorrelation statistic.

As to the coefficient estimates, it would appear that statistical evidence of imperfect competition exists for three of the inputs, namely, “Materials”, “Services” and “Industrial Employment”. Also we strongly reject the null hypothesis of equality of the market-power coefficients which provides support for the hypothesis that the source of market power lies in the pricing of the inputs to manufacturing industry and not in the pricing of outputs.

The market-power coefficient is estimated at under 1% for “Materials” but at 2.5% for “Industrial employment”. It is particularly interesting that we get a highly significant negative value for “Services” which is also of a substantial magnitude at nearly 9%. The negative value implies that industries are paying substantially more for “Services” than the internal marginal value of these inputs to industries.

To put these coefficient estimates in perspective, the exercise of market power in 1999 cost suppliers about €146 m. and €200 m. for “Materials” and “Industrial Employment” respectively. As against this, our estimates suggest that suppliers of “Services” were able to squeeze about €100 m. out of the manufacturing sector in 1999.

Table 3
OLS market-power coefficient[a] estimates for Irish manufacturing industries, 1991-1999; assuming common coefficients across manufacturing industry sectors (standard errors in parentheses)

ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	$\bar{R}^2$	**LM[b]**
0.00658 (0.00277)ss	-0.087792 (0.01880)ss	-0.00348 (0.02345)	0.00907 (0.01234)	0.02513 (0.00628)ss	0.37	-0.14 (0.91)

Key: ϕ_1 = materials; ϕ_2 = services; ϕ_3 = fuel and power; ϕ_4 = “other” employment; ϕ_5 = industrial employment.

a: The likelihood ratio test for equality of the market power coefficients produced a value of 178 with 1 dof which substantially exceeds the critical χ^2 value with 1 dof.

b: LM denotes the Lagrange Multiplier test for first-order autocorrelation which is obtained by regressing the residuals from the equation on its lagged value and the other right-hand-side variables. The values reported here are the estimated coefficient and standard error respectively obtained for the lagged residual term.

ss: denotes statistically significant at the 95% level.

3.2.2 Results allowing for variable slopes by two-digit sector

Equation (15) allows the market-power parameter values to vary across each of the 17 two-digit sectors. It was also estimated using OLS and yielded an $\bar{R}^2$ value of 0.56 and an LM-autocorrelation value of 0.17 with a standard error of 0.91. We note that with these estimates we again reject the null hypothesis of equality of the market-power coefficients for each input which provides support for the hypothesis that the source of market power lies in imperfect competition in the pricing of inputs.

The market-power coefficient estimates for each of the 17 two-digit sectors were generated using equation (15)(a) and the results are tabulated in Table 4. The hypothesis of equality of the market-power coefficients across the 17 two-digit sectors is strongly rejected with a value of 395 (80 dof) for the likelihood-ratio test.

Table 4
OLS market-power coefficient estimates for Irish manufacturing industries, 1991-1999;allowing for different[a] coefficients across the two-digit manufacturing industry sectors (standard errors in parentheses)[b]

Sector	ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5
15 Food	0.00594 (0.00170)ss	-0.04653 (0.02328)ss	-0.06143 (0.02896)ss	0.01429 (0.01705)	0.01513 (0.01135)
17 Textiles	0.00977 (0.00485)ss	-0.19169 (0.06714)ss	-0.12100 (0.05080)ss	0.09952 (0.04091)ss	0.03376 (0.01877)s
18 Wearing Apparel	0.01459 (0.00835)s	-0.03562 (0.02812)	0.02176 (0.05781)	0.01277 (0.04979)	-0.00278 (0.01661)
20 Wood & Wood Prods.	0.00161 (0.00101)s	-0.06959 (0.01796)ss	-0.01355 (0.02010)	0.01375 (0.01121)	0.01542 (0.00725)ss
21 Pulp & Paper	0.00482 (0.00107)ss	-0.00308 (0.01431)	-0.02844 (0.01860)s	-0.02798 (0.01191)ss	0.00845 (0.00437)ss
22 Printing & Rec. Media	-0.00114 (0.00148)	-0.01027 (0.01037)	0.03162 (0.03340)	-0.00725 (0.00436)s	0.00204 (0.00327)
24 Chemicals	0.01570 (0.00582)ss	-0.12557 (0.06223)ss	-0.04208 (0.04110)	-0.03576 (0.02620)	0.00387 (0.04843)
25 Rubber & Plastic	0.00147 (0.00046)ss	-0.00569 (0.00415)	-0.00064 (0.00992)	-0.00261 (0.00449)	0.00636 (0.00478)
26 Other Non-Metallic	0.00610 (0.00164)ss	-0.13159 (0.01586)ss	-0.01852 (0.00842)ss	-0.02314 (0.00696)ss	0.01643 (0.00647)ss
28 Fabricated Metals	0.00061 (0.00290)	-0.13855 (0.04015)ss	-0.09456 (0.10183)	0.04652 (0.02988)	0.05304 (0.03321)s
29 Machinery & Equipment	0.00250 (0.00066)ss	-0.03583 (0.00923)ss	-0.01316 (0.01781)	0.00298 (0.00499)	0.00449 (0.00184)
31 Electrical Machinery	0.00305 (0.00174)s	-0.04810 (0.02429)ss	0.03076 (0.04200)	0.01913 (0.01813)	-0.00201 (0.00515)
32 Radio, TV & Comm. Equip.	0.00558 (0.00084)ss	-0.07581 (0.02776)ss	0.11843 (0.11915)	0.00547 (0.01126)	-0.00818 (0.00917)
33 Med., Prec. & Opt. Instrum.	-0.00326 (0.00151)ss	-0.18827 (0.02709)ss	-0.05551 (0.04242)	0.02005 (0.01372)s	0.00656 (0.00834)
34 Motor Vehicles	-0.00037 (0.00120)	-0.03870 (0.01295)ss	-0.03356 (0.02949)	-0.00137 (0.01950)	0.01965 (0.00195)ss
35 Other Trans. Equip.	-0.01242 (0.02359)	-0.00767 (0.06643)	0.29141 (0.30646)	-0.12878 (0.09011)	0.05059 (0.03282)s
36 Furniture	0.01500 (0.00824)ss	0.02829 (0.06373)	0.03571 (0.15236)	0.03421 (0.05399)	0.02290 (0.03717)

Key: ϕ_1 = materials; ϕ_2 = services; ϕ_3 = fuel and power; ϕ_4 = "other" employment; ϕ_5 = industrial employment.

a: The likelihood ratio test for equality of the market power coefficients produced a value of 365 with 1 dof which substantially exceeds the critical χ^2 value with 1 dof.

b: $\overline{R}^2$ = 0.56; LM = 0.12 (SE = 0.93); LM denotes the Lagrange Multiplier test for first-order autocorrelation which is obtained by regressing the residuals from the equation on its lagged value and the other right-hand-side variables. The values reported here are the estimated coefficient and standard error respectively obtained for the lagged residual term.

s: denotes statistically significant at the 90% level.

ss: denotes statistically significant at the 95% level.

Consistent with our findings in Table 3, 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 returning statistically significant values for “Other Employment” and “Fuel and Power” respectively.

About eight sectors report a market-power coefficient for “Materials” that is greater than or equal to 0.5% (sectors 15, 17, 18, 21, 24, 26, 32 and 36). The surprisingly negative and large market-power coefficient that was obtained for “Services” in Table 3 is replicated for virtually every sector in Table 4. About seven sectors report a market-power coefficient for “Services” that is greater than or equal to –5% (sectors 17, 20, 24, 26, 28, 32 and 33). Around eight sectors (sectors 15, 17, 20, 26, 28, 34, 35 and 36) return an estimated market-power coefficient in respect of “Industrial Employment” that exceeds or equals 1%.

Three sectors stand out as having especially large and statistically significant market-power coefficients in respect of “Materials”, “Services” and “Industrial Employment”, namely, sectors 17 (“Textiles”), 24 (“Chemicals”) and 28 (“Fabricated Metals”).

3.2.3 Some robustness checks: influential observations

Our results so far suggest the prevalence of market power in the pricing of production inputs in a large number of Irish manufacturing sectors. Given the importance of these findings it is important that our results are subject to a series of robustness’ checks. Our first set of tests is motivated by the concern that our OLS estimates may be unduly influenced by outlier observations. The possibility of outliers is prompted by the very nature of the methodology employed to generate the results in Tables 3 and 4. If the hypothesis of perfect competition in output and input prices holds for a large number of observations then according to equation (9) the dependent variable takes on the value of zero. Where imperfect competition holds then (9) takes on non-zero values. It is possible therefore that those observations which have non-zero values for the dependent variable will unduly influence the regression results.

We employed two approaches to assess the impact of exceptional observations. First, we performed OLS on a truncated dataset which excluded outlier observations according to the criterion proposed by Belsey, Kuh and Welsch (1980)[7]. In Table 5 we report the estimates of market power that were obtained on the assumption of constant two-digit sector slopes. About 90 of the 872 observations were deemed to be "influential" according to the Belsey-Kuh-Welsch test. These results should be compared directly with those given in Table 3. These estimates serve to highlight the qualitative impact of influential observations on the magnitude of the market-power coefficients.

Table 5
OLS market-power coefficient estimates for Irish manufacturing industries, 1991-1999;assuming common coefficients across manufacturing industry sectors but excluding influential observations (standard errors in parentheses)

ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	$\bar{R}^2$
0.00244 (0.00034)ss	-0.04685 (0.00347)ss	-0.02905 (0.00760)ss	0.00116 (0.00285)	0.00665 (0.00155)ss	0.27

Key: ϕ_1 = materials; ϕ_2 = services; ϕ_3 = fuel and power; ϕ_4 = "other" employment; ϕ_5 = industrial employment.
ss: denotes statistically significant at the 95% level.

The most obvious difference between the estimates in Table 5 and Table 3 is the substantial reduction in the magnitude of the market power coefficients for "Materials" (down by about 60%), "Services" (down by about 50%) and "Industrial Employment" (down by about 75%) and the substantial increase in the size of the "Fuel and Power" coefficient which, unlike Table 3, is now statistically significant. Overall the results are qualitatively similar to those reported in Table 3 and the parameters, with the exception of the coefficient for "Other Employment", are highly significant[8].

A second estimation approach that can handle the problem of influential observations is the employment of the Least Absolute Difference or LAD estimator[9].(see Judge *et al* (1998)) The estimator minimises the impact of outliers by fitting the regression line through the median of the data rather than the mean in the case of OLS.

The LAD estimates, incorporating the assumption of constant two-digit sector slopes, are exhibited in Table 6.

Table 6

[7] I would like to acknowledge my colleague, Maurice Roche's, suggestion to use this approach. The procedure resulted in about 90 observations being discarded out of the total of 872.
[8] We also ran the model of variable-slope coefficients on the truncated sample and obtained results of a similar nature.
[9] I would like to acknowledge my colleague, Donal O'Neill's, suggestion to use this estimator.

Least Absolute Distance market-power coefficient estimates for Irish manufacturing industries, 1991-1999;assuming common coefficients across manufacturing industry sectors (standard errors in parentheses)

ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	$\overline{R}^2$
0.00217 (0.00026)ss	-0.02666 (0.00198)ss	-0.00578 (0.00430)	-0.00422 (0.00201)ss	0.00500 (0.00095)ss	0.32

Key: ϕ_1 = materials; ϕ_2 = services; ϕ_3 = fuel and power; ϕ_4 = "other" employment; ϕ_5 = industrial employment.
ss: denotes statistically significant at the 95% level.

These results are qualitatively very similar to those reported in Table 5 where we truncated the sample to exclude outliers. Relative to the OLS estimates for the complete sample in Table 3, we note that the market-power coefficients in respect of "Materials" and "Services" are about 70% lower in absolute magnitude while the coefficient for "Industrial Employment" is around 80% lower. The coefficient value for "Other Employment" is not too dissimilar as between the LAD and OLS estimates for the complete sample and is, in any case, also statistically insignificant.

In Table 7 we present the estimated market power coefficients generated by the LAD estimator but now allowing the slope coefficients to vary by two-digit sector.

Table 7
LAD market-power coefficient estimates for Irish manufacturing industries, 1991-1999;allowing for different coefficients across the two-digit manufacturing industry sectors (standard errors in parentheses)

Sector	ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5
15 Food	0.0016552 (0.00075)ss	-0.011826 (0.01042)	-0.024165 (0.02347)	-0.0030469 (0.00950)	0.0084302 (0.00623)
17 Textiles	0.0053564 (0.00127)ss	-0.065583 (0.01103)ss	-0.035388 (0.01359)ss	0.016506 (0.01844)	0.003349 (0.00433)
18 Wearing Apparel	0.014926 (0.00173)ss	-0.047181 (0.01092)ss	0.068821 (0.01690)ss	-0.051582 (0.01485)ss	-0.0029508 (0.00421)
20 Wood & Wood Prods.	0.0015771 (0.00410)	-0.043917 (0.01589)ss	-0.0002383 (0.03255)	0.000263 (0.02368)	0.009374 (0.00983)
21 Pulp & Paper	0.0040965 (0.00116)ss	0.0001882 (0.02268)	-0.019234 (0.033691)	-0.015521 (0.00966)s	0.0032912 -0.0069
22 Printing & Rec. Media	0.0004376 (0.00308)	-0.0062446 (0.01914)	0.0020526 (0.06693)	-0.004496 (0.00468)	0.0016521 (0.00322)
24 Chemicals	0.0023853 (0.00113)ss	-0.033041 (0.00943)ss	0.0038951 (0.01007)	-0.002727 (0.00857)	-0.0044804 (0.00860)
25 Rubber & Plastic	0.0014602 (0.00227)	-0.0079353 (0.02279)	0.000846 (0.05596)	0.002638 (0.01800)	-0.0010146 (0.01258)
26 Other Non-Metallic	0.004832 (0.00111)ss	-0.059132 (0.00411)ss	-0.01114 (0.00707)s	-0.011089 (0.00565)ss	0.0054426 (0.00413)
28 Fabricated Metals	0.0018641 (0.00081)ss	-0.032149 (0.00561)ss	-0.0056407 (0.02017)	0.0035323 (0.00760)	0.0044513 (0.00455)
29 Machinery & Equipment	0.0014987 (0.00111)	-0.014513 (0.01291)	-0.0063647 (0.03917)	0.0006608 (0.00956)	0.00000 (0.00404)
31 Electrical Machinery	0.0016192 (0.00109)s	-0.017278 (0.01037)s	0.016068 (0.03639)	0.0010228 (0.00937)	0.000941 (0.00506)
32 Radio, TV & Comm. Equip.	0.0038342 (0.00092)ss	-0.061462 (0.03073)ss	0.023516 (0.12890)	0.017355 (0.01102)s	-0.0026887 (0.01097)
33 Med., Prec. & Opt. Instrum.	-0.0060158 (0.00333)s	-0.20872 (0.03080)ss	-0.1153 (0.09407)	0.038914 (0.02731)	0.02051 (0.01683)
34 Motor Vehicles	-0.0011962 (0.00228)	-0.023278 (0.01552)s	-0.042503 (0.05921)	0.017655 (0.03136)	0.018413 (0.00472)ss
35 Other Trans. Equip.	0.0024885 (0.00086)ss	-0.037978 (0.00463)ss	0.050381 (0.02249)	-0.064264 (0.00787)ss	0.020924 (0.00284)ss
36 Furniture	0.0040022 ('0.00213)s	0.0005567 (0.01524)	-0.024547 (0.04561)	-0.0057968 (0.01696)	-0.0014583 (0.00819)

Key: ϕ_1 = materials; ϕ_2 = services; ϕ_3 = fuel and power; ϕ_4 = "other" employment; ϕ_5 = industrial employment.
$\overline{R}^2$ = 0.28.
s: denotes statistically significant at the 90% level.
ss: denotes statistically significant at the 95% level.

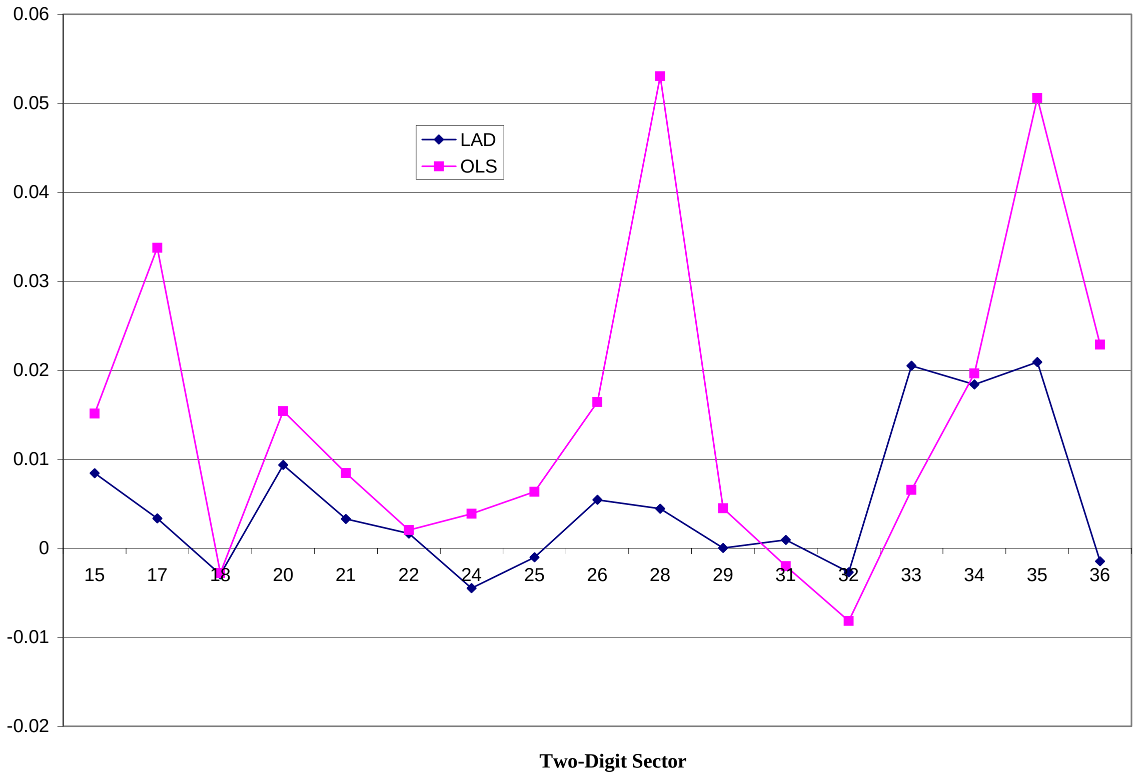
If we contrast these results to those reported in Table 4 for the complete-sample OLS estimates, we note that the LAD estimates essentially reduce the magnitude of those coefficients that would appear to be outliers in the OLS set of estimates. Thus we find a reasonably close correspondence between the estimates for "Materials" with the exception of sectors 34 ("Motor Vehicles "), 35 ("Other Transport Equipment") and 36 ("Furniture"). For "Services", we observe that the predominance of negatively-signed coefficients is replicated but there is a much lower concordance in the two sets of estimates, although there is a notable tendency for the LAD estimates to be systematically lower than the OLS estimates. The coefficients for "Industrial Employment" are qualitatively very similar to the OLS estimates, although we can now only report statistically significant coefficients for sectors 34 ("Motor Vehicles ") and 35 ("Other Transport Equipment "). The OLS estimates produce coefficients of substantially greater magnitude for sectors 17 ("Textiles"), 28 ("Fabricated Metals "), 35 ("Other Transport Equipment ") and 36 ("Furniture ").

As an illustration of the nature and scale of the differences obtained between the LAD and OLS estimates for the complete sample we depict the coefficients obtained for both estimators in the case of "Industrial Employment" in Chart 1[10].

[10] Essentially similar pictures are obtained for the other inputs.

Chart 1

LAD and OLS (Complete Sample) Market Power Coefficients for "Industrial Employment" by Two-Digit Manufacturing Sector



3.2.4 Robustness checks: economies of scale

We have not alluded so far to the possibility that the findings of imperfect competition could be at best contaminated by, or, at worst be mistaken for, scale effects. Our reluctance to confront this conundrum so far is because of the huge difficulty in satisfactorily distinguishing empirically between imperfect competition and scale effects with the Hall-Roeger methodology. Kee (2002) shows that it is in principle possible to derive an expression for the difference between the Solow quantity and price-based residuals which is a function of a market power and a scale term. Thus by modifying equation (13) as follows

$$y = \sum_{j=2}^{M} \phi_j z_j + (S_k - 1)[(\Delta x_1 + \Delta w_1) - (\Delta p + \Delta y)] + \varepsilon \qquad (16)$$

where, S is the actual sum of input shares which may differ from unity and k =1,…, M, it would appear possible to simultaneously test from departures from competitive pricing and constant returns to scale. Unfortunately, equation (16) is non-estimable due to perfect collinearity between the right-hand-side variables as will be apparent upon examination of equation (10)[11].

The best we believe that can be done is to add a scale term to the specification in equations (14) or (15) which will not be perfectly collinear with the market-power term. Thus we re-ran equation (14) using the LAD estimator and added the log-change in the value of gross output $(\Delta p+\Delta y)$ as an additional right-hand-side variable. The results are given in Table 8. It is apparent that the inclusion of the output term does not affect the magnitude of the market-power coefficients and is itself not statistically significant. However, it has to be noted that this equation will also suffer from multicollinearity so we cannot be emphatic about the apparent non-importance of scale terms[12].

Table 8

LAD market-power coefficient estimates for Irish manufacturing industries, 1991-1999;assuming common coefficients across manufacturing industry sectors and including a scale term (standard errors in parentheses)

ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	$(\Delta p+\Delta y$	$\overline{R}^2$
0.002159 (0.00027)ss	0.027246 (0.001985)ss	-0.005548 (0.004386)	-0.00461 (0.002029)ss	0.005131 (0.00095)ss	0.000042 (0.00014)	0.32

Key: ϕ_1 = materials; ϕ_2 = services; ϕ_3 = fuel and power; ϕ_4 = "other" employment; ϕ_5 = industrial employment.
ss: denotes statistically significant at the 95% level.

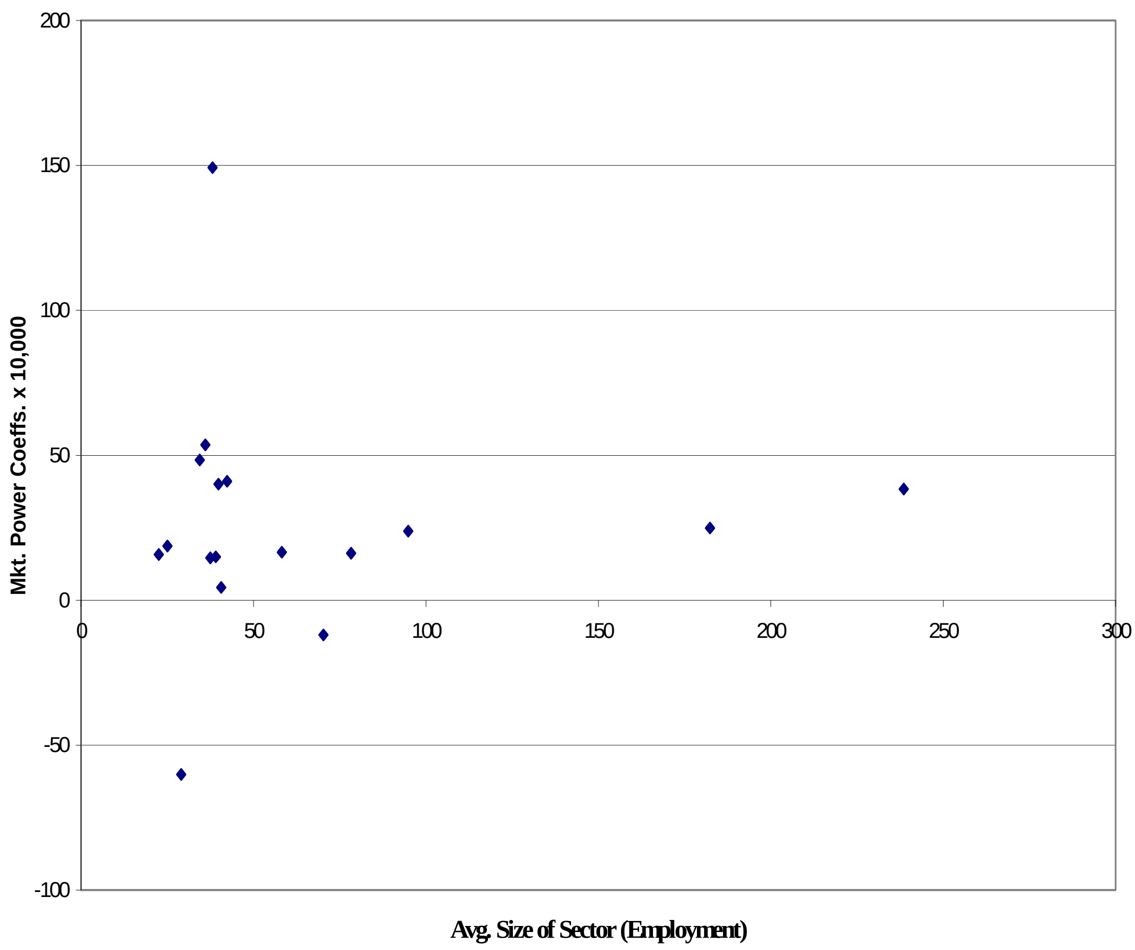
A less rigorous attempt to explore potential scale effects was implemented by examining the relationship between the estimated market power coefficients at the two-digit level and indicators

[11] Kee (2002) argues that equation will tend to zero because "… the shares of input in total revenue are mostly constant in the real world …" (p. 11). As it happens this is not true with our dataset but in any event there is no need to draw on such a stylised fact to motivate why (16) cannot be estimated given the argument made in the text.

[12] It would naturally be preferable to include a demand term as a scale variable but none would appear to be available at the four-digit manufacturing-industry level.

of scale such as the average numbers employed per local manufacturing unit in each sector[13]. This analysis could establish no systematic relationship. Typical of the kind of relationship that was revealed is given in Chart 2 for the case of the "Materials" input.

Chart 2
LAD Market Power Coefficients ("Materials") and Employment by Two-Digit Sector



[13] We also used the level of gross output per local manufacturing unit in each sector but the findings were virtually

4. Concluding remarks

This paper has applied Roeger's version of Hall's ingenious non-parametric test of market power to Irish manufacturing four-digit industries. The paper demonstrates the equivalence of so-called "monopoly" and "monopsony" 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 monopolistic and monopsonistic departures from competitive pricing.

A number of the findings are worth noting. We find evidence of statistically significant market power in the pricing of key production inputs. We strongly reject the constancy of slopes at the two-digit sector level. Our results also suggest that the source of market power is most likely to arise in the pricing of inputs rather than outputs. This finding confirms the strong prior of pricing-taking behaviour in output markets which has been confirmed in several previous studies.

We do, however, find evidence that our estimates of the degree of market power are affected to a significant extent by influential observations. While the statistical significance of the market-power coefficients is not unduly affected by the employment of estimation approaches that take account of such observations, the magnitudes of the coefficients are affected mainly in a downward direction and especially for a handful of 2-digit sectors.

While acknowledging the unsatisfactory nature of our attempt to allow for scale effects, we failed to uncover any strong evidence that our estimates of market power were contaminated by scale effects. This is an issue that merits further investigation.

Based on the Least Absolute Distance estimator, our findings strongly suggest that Irish manufacturing industries, taken as a whole, exercise statistically significant market power, albeit to a modest extent, in purchases of "Materials" and "Industrial Employment". In the case of "Materials" we report an overall market-power coefficient of about 0.2% and for "Industrial Employment" we find a value of about 0.5%.

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identical.

These coefficients are evidently relatively modest in absolute size. For instance, it would appear very improbable that the market-power coefficient for “Industrial Employment” would be sufficient in general to cause employment to increase in response to increases in the minimum wage. We wouldn’t be as confident in this expectation for the handful of sectors (“Food”, “Wood and Wood Products”, “Medical, Precision and Optical Instruments”, “Motor Vehicles” and “Other Transport Equipment”) where the market-power coefficient is much greater than 0.5%.

In many respects the most surprising result is the statistically significant and relatively large negative market-power coefficient that is obtained for “Services”[14]. For the full set of manufacturing industries, the coefficient implies that the price paid for this input is about 2.7% less than the internal marginal value of this input to the sector as whole. Relative to 1999 outlays this would suggest an annual cost burden to industries of about €30 m..

Our analysis allowed the market-power coefficients to vary across each two-digit sector. In respect of the “Materials” and “Industrial Employment” coefficients we find that a handful of sectors are highly influential in determining the overall coefficient for the full set of sectors. A greater consistency in the coefficient values across the 17 two-digit sectors is, however, revealed for the “Services” input. It would seem to be worth examining the extent to which the market-power coefficients vary within those two-digit sectors that appear to have prominent values.

A final thought is whether the orders of magnitude of departure from competitive input pricing that are uncovered in this paper should attract the interest of the Competition Authority or indeed whether the Authority should be unduly concerned at all by monopsony-type behaviour!

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

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