Wages, Leisure, and Productivity in South Wales Coalmining, 1874-1914: An Economic Approach

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I.

One of the more striking phenomena of labour history is the apparent existence for certain occupational groups of a 'backward bending' supply curve of labour. 'In brief, the concept implies that an increase in the demand for labour, expressed through an increase in its price with a rise in wages, will result in a lowering of supply.' This is notable because it is contrary to the standard notion of upward sloping supply curves in which greater quantities of resources are offered at higher prices. 'In competitive conditions, assuming no absolute limitations on supply — either of existing labour willing to increase their working hours or extra labour willing to come into the market — the assumption governing 'rational' operation of a market is that extra demand, bidding up the price of a factor, will call forth extra supplies, ...' The existence of a backward bending supply curve of labour is particularly relevant for the South Wales coal industry since miners were frequently 'accused' of having a propensity to behave in such a manner. As an Inspector of Mines commented about Monmouthshire colliers in 1873, "It is not that the men want to get very large wages. I do not believe that they do; but they want short hours and more leisure, and a higher price for their piecework." This behaviour, if factual, has important implications for labour productivity and profitability in the entire industry. Labour supply, as reflected in both the hours and intensity or work offered at various wage rates, was largely within the miners' control and was an important determinant of measured labour productivity.

The trends of both wages and productivity in South Wales coalmining are well known. Following a decline in the late 1870s, wages generally rose (with periodic setbacks of limited duration) up to 1914. On the other hand, labour productivity, conventionally measured by average annual output per man, tended to fall, except that the decline was arrested between about 1892 and 1906. Interestingly, this period of declining or stagnant labour productivity was also a period of increased profitability in the coalmining industry. Economic historians have displayed a keen interest not only in declining labour productivity per se, but also in the role coalmining played in the now infamous "climacteric" of the era. There is a rich and growing literature on the broader problem of the downward shift in the performance of the British economy in the late nineteenth century. This setback has often been attributed to, among other things, the "failure" of the British entrepreneur, represented by his seeming unwillingness to adopt the best available techniques of production. This was considered to be an especially serious problem in South Wales, where the mechanical coal cutter was particularly slow to be adopted, although this was almost certainly due more to the nature of the seams than to any failure on the part of the mineowners.
These important trends in wages and productivity may also have had significant effects on the labour movement. For instance, L. J. Williams has suggested that unions in South Wales became more active during the 1890s, with the strike of 1898 as a watershed, and that this vigorous activity was a response to economic conditions, namely the strains on the worker implicit in declining productivity. As Williams stated, "For the hewers, who were the most important section of the miners the vital consideration was that their earnings were directly related to output. The piece rate basis meant that the declining trend in productivity reacted adversely upon their earnings — their annual output was tending to fall and, other things equal, this would reduce their annual earnings. They thus had a strong incentive, even apart from any efforts at improvement, to press for the wage bargain to be revised in their favour."

What Williams fails to consider is the possibility of a backward bending supply curve for labour — that declining productivity may have been in part a response to higher wages, induced through the mechanism of miners choosing to consume a part of their greater potential income in the form of increased leisure and reduced work intensity.

The purpose of this paper is to summarize some current research in which we have employed an economic framework to examine the major determinants of labour productivity in the South Wales coalmining industry between 1874 and 1914. While labour supply, as reflected in hours of work, absenteeism, and work intensity, is an important determinant of productivity, it is not the only factor. In addition, such factors as the business cycle and price of coal, capital intensity and technological change, diminishing returns inherent in extraction of an exhaustible resource, labour strikes, and mandated hours legislation are all likely to have played a role in the determination of labour productivity. In our research, we have estimated a statistical model which attempts to measure and isolate the separate effects of each determinant of labour productivity. While data deficiencies, as well as methodological considerations, prevent any definitive conclusions regarding causation, we believe our analysis sheds light on the issues surrounding the determination of labour productivity during this period.

II.

To this date the most comprehensive treatment of labour productivity in the South Wales coal industry has been made by R. H. Walters. Walters, interested in explaining the fluctuations in labour productivity in steam-coal mines examined seven potentially important determinants: hours of work, intensity of work, opportunity for working imposed by the state of the coal trade, voluntary absenteeism, quality of labour input, diminishing marginal returns, and technological change. He concluded that although factors such as the Eight Hour Act of 1908 and voluntary absenteeism may have been contributing factors to declining output per man, the rising trend of wage rates and diminishing returns inherent in the industry were the major factors leading to the observed result. These could have been, but were not, offset by technological change in South Wales.

Walters' careful study is most notable for its descriptive analysis and detailed collection of data. Indeed, our own analysis has relied heavily on these data. While Walters carefully
compared trends among pairs of variables, he did not provide the type of statistical analysis which would allow him to reliably estimate the separate impact of each factor on labour productivity, after controlling for the effects of all other determinants. Walters' rich base of data does provide an opportunity, however, to examine more precisely the relationships between labour productivity and its determinants and to appraise some of those issues under discussion among economic historians.

Following Walters' lead, we hypothesize that labour productivity is determined by wage rates, work effort, the state of the coal trade (or business cycle), diminishing returns in mining, and technological change. In a more perfect world, we would have precise measures of all these important variables. Since the world is not perfect, it is necessary do make to with data that exist, so that empirical estimation of such a model is determined in part by data availability. Before presenting our findings, it is useful to discuss the measures we have selected to represent the above concepts.

As a measure of labour productivity, we follow convention and use the annual average output (in tons) divided by the number of workers above and below ground. As is true in most historical studies, our measure of productivity fails to reflect truly homogenous labour units. Observed productivity is affected by labour quality and skill type (for instance, the ratio of hewers to oncost workers), hours of work per shift, absenteeism, strikes, and work intensity. While we can explicitly account for strikes and mandated hours legislation, we do not have complete data on these other aspects of labour supply.

Wages are measured both by a money wage rate index and by an index of wage rates adjusted for changes in the price level (i.e., real wages). We doubt that miners could be fooled over any length of time into believing that their wages were rising if they failed to keep pace with rising prices (and vice versa during deflation), but it is safer and more inclusive to use both measures of compensation, in part due to some unreliability in available price indices.

The existence of a major strike in any given year could have a profound effect on output in that year. To estimate this effect, we constructed a "dummy" variable, which statistically accounts for the uniqueness of those years in which strike activity was important. While some judgment is required in deciding what constitutes a major strike, we counted the years 1874, 1875, 1893, 1899, 1910, 1911, and 1912 as strike years in South Wales.

We also included a "dummy" variable to account for the effects on average output per man of the Eight Hour Act of 1908. This act had potentially important effects in South Wales, since prior to its enactment the hours of working in South Wales were significantly above both eight hours and the average for all of Britain.

In order to capture the effects of the business cycle on productivity, we utilized the percentage change in British trade (domestic exports plus imports) as a measure of the state of the coal trade. Since such a large share of South Wales coal was exported, and because a major use of steam coal was in transport, this variable seems a most appropriate measure. As an alternative measure of the state of the coal trade, we have elsewhere employed the percentage change in gross domestic product and obtained similar results. As in the case of wages, we used both nominal and real (price adjusted) trade figures.
Constructing a precise measure of diminishing returns to mining proved particularly difficult. As existing mines produced output they grew both larger and older. Using data from twenty-two steam coal companies, Walters found that the proportion of output coming from older pits increased over time (by 1913, 72 percent of output came from pits working 20 years or more). As the coal faces of these older pits retreated from the shaft, diseconomies tended to grow. The best, but admittedly far from perfect, measure we have for this phenomenon is average mine size, which we believe to be associated with diminishing returns, thus acting to decrease labour productivity.

Although technological innovations would have had a positive effect on productivity, few innovations (specifically, mechanical coal cutters) were adopted in South Wales. To capture the modest effects of technological change we included a time variable (year) in the model. A time variable can be viewed as ‘a catchall for the resultant of those factors which cannot conveniently be measured separately, but which change more or less smoothly.’ Thus, the time variable will also capture any determinants of labour productivity that have a secular trend and are measured imperfectly by the model’s other variables.

III.

The results of statistically estimating several versions of the model discussed above are presented in Table 1. The crucial question, of course, is what have we learned from this exercise? Below we discuss the findings from our statistical model in some detail. The hypothesis that labour productivity declined in response to higher wage rates was strongly supported by our results. We found that there existed a significant negative relationship between productivity and wages (nominal or real) after accounting for other measurable determinants. Our estimates indicated that, for example, a 10 percent increase in wage rates was associated with something like a 2.6 to 4.3 percent decrease in labour productivity. This empirical finding is consistent with both the casual empiricism regarding that period and with the numerous current studies finding a backward bending labour supply function for prime-age males. Because of data limitations, we are unable to identify the exact manner in which reduced output per worker took place in response to higher wages. It undoubtedly consisted of some combination of reduced work intensity and greater absenteeism, possibly combined with reduced regular hours of work.

It should be noted that even though ‘leisure’ increased and productivity decreased in response to rising wages, this does not imply that mineowners, individually or in concert, could have effectively reversed this trend by paying lower wages. Individual mineowners had to pay a wage similar to the going market wage in order to attract a sufficiently skilled and sizeable group of miners, while the industry as a whole, to the extent that they could act together and pay a common wage, had to agree to a wage high enough to attract the desired number of workers into the industry.
### Table 1
The Determinants of Labour Productivity (annual output per man), 1874-1914: Summary of Regression Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range of Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOMINAL WAGE</td>
<td>-.433 to -.261</td>
</tr>
<tr>
<td></td>
<td>(-3.35 to -1.91)</td>
</tr>
<tr>
<td>REAL WAGE</td>
<td>-.276 to -.258</td>
</tr>
<tr>
<td></td>
<td>(-2.24 to -2.18)</td>
</tr>
<tr>
<td>STRIKE</td>
<td>-.169 to -.157</td>
</tr>
<tr>
<td></td>
<td>(-6.55 to -5.66)</td>
</tr>
<tr>
<td>EIGHT HOUR ACT OF 1908</td>
<td>-.094 to -.064</td>
</tr>
<tr>
<td></td>
<td>(-1.69 to -1.14)</td>
</tr>
<tr>
<td>% CHANGE IN NOMINAL TRADE</td>
<td>.0020 to .0026</td>
</tr>
<tr>
<td></td>
<td>(.71 to 1.53)</td>
</tr>
<tr>
<td>% CHANGE IN REAL TRADE</td>
<td>.0037</td>
</tr>
<tr>
<td></td>
<td>(1.71)</td>
</tr>
<tr>
<td>AVERAGE MINESIZE</td>
<td>-.0025 to -.0010</td>
</tr>
<tr>
<td></td>
<td>(-2.06 to -.65)</td>
</tr>
<tr>
<td>TIME</td>
<td>.0050 to .011</td>
</tr>
<tr>
<td></td>
<td>(.87 to 2.18)</td>
</tr>
</tbody>
</table>

R²: .699 to .952

**EXPLANATION OF TABLE:** The "range of estimates" column expresses the direction and magnitude of the effect of each variable on labour productivity with all other variables statistically held constant. A negative sign indicates an inverse relationship between that particular variable and labour productivity, while a positive sign indicates a direct relationship. The figures in parentheses are "t" statistics, which test the hypothesis that the estimate is actually equal to zero. A standard criterion is to be 95% certain that the estimate is not zero. In this case any "t" statistic less than -1.69 or greater than +1.69 passes this test, so that the particular variable is said to be "significant". The "R²" at the bottom of the table is the "coefficient of determination", which measures how well all the variables together acted in explaining labour productivity. The closer this measure is to 1.0 the better the explanation.

The principal determinant of short-run fluctuations in wage rates was the variability in the selling price of coal. For much of the period under discussion, wages were determined by the sliding scale, which related wages to the selling price of coal. Up to 1880 a minimum and maximum were in effect, the minimum being wages paid in 1869 + 5 per cent, the maximum
not to exceed 67.5 percent of the standard. For every one shilling change in the price of coal, wages were to be adjusted by 7.5 percent. After 1880, there was neither a minimum nor a maximum and adjustment was more frequent. In 1903, the sliding scale was replaced by a conciliation board. After a strike by the Miners' Federation in 1912, the Coal Mines (Minimum Wage) Act, 1912 (2 Geo V Ch. 2) took effect. The minimum for a South Wales collier, normally a piece rate worker, who was prevented from working by a fault in the seam or other cause beyond his control, was 4s. 7d. per day.25

In our empirical work elsewhere, we have constructed a more complex model in which wage rates are first determined by current and past prices of coal, and then in turn influence labour productivity. We estimated that a 10 percent increase in coal price was associated with about a 6.5 percent increase in wages, which then led to a reduction in measured productivity via labour supply responses. The interrelationship between price, wages, and productivity also helps explain the apparent paradox of increased profitability during the later part of the period. 'Coalowners, indeed, were inclined to measure the efficiency of their industry not so much in terms of physical output as of financial successes, ... and its best years prove to be those after 1900 in which output per man year was declining most rapidly.'26 The paradox is resolved when it is realized that a strong demand led to high prices and profits for mineowners, yet also brought about increasing wages and decreased productivity as miners worked fewer hours, decreased work intensity, and increased absenteeism.

While wage rates were found to have important effects over this period, they were hardly the sole determinant of labour productivity. Output per worker decreased significantly during strike years. The results in Table 1 suggest that measured productivity was 16 to 17 percent lower during strike years than non-strike years. We are unable to say to what extent this reduction resulted from fewer work days. It is quite possible that work days on average fell by more than these percentages, but that colliers and mineowners worked more intensely during the rest of the year in order to partially make up for losses in income.

The Eight Hour Act of 1908 was also found to have had the anticipated effect on labour productivity. We found that output per worker was approximately 6 to 9 percent lower in South Wales from 1909 to 1914 than it would have been in the absence of the hours legislation. While the actual hours of work apparently decreased by more than this, it is likely that a compensating increase in work intensity mitigated partially the effect of the hours law.

The effect of the business cycle on labour productivity, as indicated by the estimates for the percentage change in nominal and real trade, was positive as predicted, but does not appear to have been large after accounting for other determinants. Indeed, the 't statistics' are sufficiently low such that these results are not statistically significant (that is, the estimates for this variable presented in Table 1 cannot often be said to be distinguishable from zero). The most important factor generating pro-cyclical labour productivity was probably the policy of 'short working' in recessionary times, whereby owners reduced the number of days in which a colliery wound coal. Also the practice of 'stinting' on output during slack periods may have existed. Walters suggested that colliers would impose stinting on themselves 'in order to maintain the selling price of coal and maximize employment'.27 However, it is unlikely that individual colliers, or even individual mineowners, could have significantly affected price;
thus, such behaviour was unlikely. In the longer term the adverse effects of higher wages during good times prevailed over the opportunity to increase productivity through full and regular working.

Average minesize, measuring (quite imperfectly) diminishing returns in mining, was found as expected to be negatively, though not always significantly, related to output per worker. It appears that diminishing returns almost certainly played a role in bringing about declining labour productivity, though we are unable to measure this relationship in a precise way.

Finally, we found a small (from .5 to 1.1 percent per year), though not always statistically significant, positive time trend in labour productivity over the 1874-1914 period, after accounting for other determinants. We hypothesized that time primarily captures the modest effects of technological change in South Wales mining. Coalmining in South Wales did not easily lend itself to mechanical coal cutting machines and other technological advances. The modest progress that took place may very well have been in the form of improved winding apparatus and underground haulage. The variable may also be capturing any unmeasured determinants of labour productivity which had a regular and positive effect over the years. The absence of a negative time trend suggests that the hypothesis of entrepreneurial "failure" is incorrect; there exists no secular decline in productivity after accounting for wages, strikes, hours legislation, the business cycle, and diminishing returns.

IV.

Perhaps the most striking and persistent finding of this whole endeavour has been the apparent confirmation that productivity tended to decline when wage rates rose. It is quite possible that defects in the model as well as data limitations are contributing to this result. Annual output per man employed is, of course, a crude measure of productivity. At the very least, it would be preferable to have figures for output per man-hour (broken down for hewers and oncost workers). Data on the amount of capital per worker and a more suitable measure of diminishing returns due to the necessity of working less suitable seams would generate much more satisfactory estimation. But what if under those conditions the inverse relationship between wages and productivity was again confirmed? Does this in any way represent an indictment of the behaviour of the miners? The answer is a most emphatic no. First, in aggregate terms the achievements of the miners were remarkable. Average annual output in South Wales increased from 14.8 million tons in 1871-75 to 52.8 million tons in 1911-14, an increase of 257 percent. Total persons employed above and below ground increased from 73,000 in 1874 to 234,000 in 1914, an increase of 221 percent. Aggregate labour supply, as expected, expanded with increased demand for coal and generally rising wage rates. Indeed, the increase in wages was almost certainly necessary to attract this many new workers into the mines. To some extent, of course, the observed decline in productivity was a phenomenon over which the miner had no control. As L. J. Williams has stated, 'The obvious way out of this impasse was by the adoption of new technological methods which would raise productivity and reverse the adverse trends of costs and earnings. It is often said that the South Wales owners were reluctant innovators and that the workmen strongly
opposed new methods. But, as Williams pointed out, the ultimate stumbling block was neither the miner nor the owner, but the less than ideal geological conditions.

While increased numbers of miners were attracted into the fields by the increasing demand for coal and rising wages, their preference for fewer and less intense hours of work once employed in the industry should be viewed as quite typical. Certainly it is no indictment of the labourer to observe that a portion of his higher potential income was taken in the form of increased leisure. In fact, it should be viewed as progress; leisure has economic value, just as does market output. Finally, it may be argued that in this study we have removed the blood, sweat, and tears from the labouring process. Moreover, we have given little indication that the miner, individually or through his trade union organization, had to struggle for these, perhaps modest, gains. We hope, however, to be forgiven for what is perhaps too narrow a focus and trust that this endeavour has increased somewhat our understanding of this interesting period of history.

FOOTNOTES

2. Ibid.
4. See R. H. Walters, The Economic and Business History of the South Wales Steam Coal Industry, 1840-1914 (1977), Ch. V. Money wages on average were 33% higher in 1907-14 than in 1874-81. After adjusting for changes in the price level, wages were 46% higher in 1907-14 than in 1874-81. Average annual output per man above and below ground was 7% lower in 1907-14 than in 1874-81. See Walters' book (1977), pp. 360-61.
7. Ibid., p. 10.
11. Walters' article (1975), p. 300 There was little change in the ratio of below ground to above ground workers during this period, so that results using only below ground workers would not alter the conclusions.
12. Ibid.


17. The price index was obtained from ibid., p. 476.

18. Walters' book (1977), p. 261. In 1918, 31 percent of Monmouthshire and South Wales miners had to travel a mile or more underground from pit bottom to working place. See Finlay A. Gibson, *Statistical Summaries ... Submitted on Behalf of the Mining Association of Great Britain to the Commission of Inquiry re Miners’ Wages and Hours* (1919).

19. Walters' book (1977), pp. 269-70. Average mine size is obtained by dividing annual total output by the number of mines in existence.

20. In 1911 the total number of mechanical coal cutters in Britain was 2,146, only 113 of which were in South Wales; Davies and Hailey, *South Wales Coal Annual* (1913). As late as 1938 only 26 percent of coal produced in South Wales was cut by machines. This was by far the lowest proportion among the coal districts of Britain. See E. C. Rhodes, "Output, Labour and Machines in the Coal Mining Industry in Great Britain," *Economica*, new series 12 (1945), p. 101.


22. The authors will gladly provide supplementary material to any reader who wished a fuller discussion of the methodology used to obtain these estimates. Please direct such requests to W. J. Hausman, Department of Economics, College of William and Mary, Williamsburg, Virginia 23185.

23. In estimating the model we used the natural logarithms of both wage rates and labour productivity so that the estimate for wage rates could be interpreted in this manner.


28. See M. W. Kirby, *The British Coalmining Industry, 1870-1946* (1977), p. 8. Improvements in cleaning and screening operations may also have made a modest contribution. See William Phillips, *South Wales Coal Buyers' Handbook* (1924). Specific colliery companies were undoubtedly on the leading edge of technological innovations. The Cambrian Collieries had undertaken the conversion from steam to electric power of their underground and surface engines, and by 1907 had replaced all but two of their fourteen boilers with electric power generated in their own station. See Joseph Davies, *The South Wales Coal Annual* (1907). Such innovative activity did not necessarily endear an owner to his workers, as D. A. Thomas the owner of the Cambrian Colliers, was 'perhaps the most vilified coal-owner in South Wales;' Deian Hopkin, "The Merthyr Pioneer 1911-22", *Llafur*, 2 (1979), p. 55.


30. Ibid., pp. 353-54. Brinley Thomas noted that the percentage increase in the population of Glamorgan between 1861 and 1911 was equal to that of all England and Wales between 1811 and 1911. "The Migration of Labour into the Glamorganshire Coalfield (1861-1911)," *Economica*, X (1930), pp. 275-94.