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How did the Location of Industry Respond To Falling Transport Costs in Britain Before World War I?

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Nicholas Crafts and Abay Mulatu

Abstract

This paper explores the location of industry in pre-World-War-I Britain using a model that takes account both of factor endowment and also of new economic geography influences. Broadly speaking, the pattern of industrial location in this period was quite persistent and regional specialization changed little. The econometric results show that factor endowments had much stronger effects than proximity to markets, although the latter was an attraction for industries with large plant size. Overall, falling transport costs had relatively little effect on industrial location at a time when proximity to natural resources, notably coal, mattered most.

Introduction

The nineteenth century British economy is often described in terms of a North-South divide. Regional specialization is usually explained in terms of endowments of coal and its attraction to the Victorian staple industries for which it was an important input because of steam power.[1] At least until the railway age, there were pronounced differences in coal prices in different localities with the most expensive about six times the cheapest.[2] It is generally accepted that the basic pattern of industrial location was established during the canal era and not seriously disturbed by the advent of the railway.[3] Certainly, once established, industries

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1 See, for example, Langton and Morris, "Introduction", Lee, *Regional Economic Growth,* and Pollard, *Peaceful Conquest*.

2 von Tunzelmann, "Coal".

3 Gourvish, *Railways*, p. 31.

benefited from external economies but at mid-century proximity to natural resources rather than to markets is the major theme in the literature.[4]

At some point late in the nineteenth or early in the twentieth century a different rationale for industrial location started to emerge. Once electricity became available as an alternative source of power industry had more freedom to move away from coalfields while increasingly complex products and mass production techniques came to the fore.[5] These developments are seen as encouraging manufacturing firms to favor central locations close to key suppliers and well-placed to serve large markets. Marked changes in the location of engineering and vehicles are seen as characteristic of these tendencies.[6] This perspective resembles that of the New Economic Geography (NEG) while the traditional account of the nineteenth century economy is more akin to the predictions of a Heckscher-Ohlin (HO) model based on factor endowments.[7]

The descriptions in the British historiography are informal both in the sense that they are not grounded in economic theory nor have they been formulated as testable hypotheses and subjected to quantitative scrutiny. This is in sharp contrast with the economic history of American industrialization.[8] In particular, despite continual discussion of the role of transport costs in the spatial distribution of economic activity there has been no examination of this in a framework of general equilibrium analysis.

The new economic geography has formalized a number of propositions regarding the pull of centrality that are of interest in this context. At bottom, these can be summarized as predictions that when

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[4] Hudson, "Regional Perspective".
[5] Lee, *Regional Economic Growth*.
[6] Dennison, *Location of Industry*; Hume and Oglethorpe, "Engineering".
[7] For the former see Venables, "Equilibrium Locations" and for the latter, Richardson and Smith, "Sectoral Growth".

transport costs are very high or very low economic activity will be spatially dispersed but when transport costs enter an ‘intermediate’ zone firms' location decisions involve consideration of market access as well as production costs. When transport costs are 'intermediate' it may be advantageous to locate near to industrial customers and suppliers and increasing returns industries may also prefer to locate their (large) plants at central locations.[9]

Thus, at some point, falling transport costs supplement the factor endowment arguments with a market access explanation of industrial location. This could happen in the context of improvements to an existing transport technology rather than await the introduction of a new mode. So, although the increasing attraction of central locations and diminishing appeal of outer Britain has often been linked to the arrival of motorized road haulage, continuing reductions in the cost of rail freight and coastal shipping may eventually have had similar implications. Regional market potential is fundamental to the pull of centrality and this was increasing at a varying pace across British regions as World War I approached and both regional incomes and also the proximity of foreign markets were exposed to globalization.[10]

Looking at the economy through this lens might have ramifications for the measurement of economic benefits from transport improvements. Gary Hawke who estimated the social savings of railways explicitly recognized this as follows: "If as a result of the establishment of railways, a particular industry became more concentrated geographically, and if this resulted in a lowering of the real costs of that industry, then the establishment of the railways has given the economy the equivalent of extra resources. The railways have then contributed to economic growth

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[8] Kim, "Economic Integration" and "Regions".
[9] Venables, "Equilibrium Locations".
[10] Crafts, "Market Potential". For the definition of market potential and some estimates , see below.

in a way that is not reflected in the social saving."[11] These are exactly the impacts envisaged by the new economic geography and simulations of calibrated models of this type suggest that total economic benefits might easily be much larger than the transport benefits.[12] Looking at the early decades, Hawke concluded that his social saving estimate did not need to be adjusted to allow for such externalities since the location of industry was not affected by the advent of the railway.[13]

An alternative way to estimate the contribution of a new technology to economic growth would be to use growth accounting techniques. In that context, the cost reductions that flowed from induced decreases in the real costs of transport-using industries would be reckoned as spillover effects on total factor productivity (TFP) growth. Nicholas Crafts recently examined the impact of steam (including both railways and steamships as well as stationary steam engines) on British economic growth using a methodology of this kind.[14] He found that the main impact of steam was felt after 1850 but was unable to include TFP spillovers in his analysis. However, he noted that if steam-powered transport had effects of this kind it would strengthen this finding with respect to the chronology of steam's contribution to growth.

In the light of this discussion, in the rest of the paper we provide a description and econometric analysis based on a reduced form equation derived from a general equilibrium model of the location of industrial employment at the 2-digit level for Britain in the decades from the railway age to World War I. This is used to address the following questions:

1) What happened to the location of industry over time?

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[11] Hawke, *Railways*, p. 382.
[12] Venables and Gasiorek, "Welfare Implications."
[13] Ibid., pp. 392-5.
[14] Crafts, "Steam as a General Purpose Technology."

2) What happened to market potential as globalization impacted the economy?
3) Is there evidence that the location of industry responded to the pull of centrality as transport costs fell?
4) What implications are there for measurement of the contribution of steam-based transport to economic growth?

Regional Specialization

In order to analyze regional specialization it is appropriate to employ location theory. There are two obvious possibilities, namely a HO-type factor endowment hypothesis or a NEG market access hypothesis. They both rely on the interaction of regional characteristics with industrial characteristics. The rationale for the emphasis on these interactions lies in the general equilibrium nature of the system. Thus, HO theory predicts that industries which use a factor of production intensively will tend to locate in regions which are abundantly endowed with that factor while NEG theories predict that the attraction of a region's market potential is greater the more an industry sells to or buys inputs from other industries. These theories should probably be regarded as complementary rather than mutually exclusive and our empirical analysis will therefore be based on a model recently proposed by Karen Midelfart-Knarvik et al. which encompasses them both.[15]

The Midelfart-Knarvik et al. model can be written as a reduced-form equation to explain a dependent variable which is the share of each region in total British employment in each industry. The independent variables are controls for size, country characteristics, industry intensities

[15] Midelfart-Knarvik et al.., "Location of European Industry".

and interactions between regional and industrial characteristics. In our implementation of the model we will consider the following six interactions: educated worker availability and educated worker intensity, coal abundance and steam power use, share of agricultural employment and agricultural input use, market potential and plant size, market potential and sales to industry, and market potential and intermediate input use. The first three of these interactions are predicted by the HO theory based on factor endowments; the last three are predicted by NEG to be activated when transport costs are at the right 'intermediate' level such that the pull of centrality kicks in.

How did regional specialization evolve in the period 1841 to 1911? Table 1 sets out regional shares of employment by industry (which in logarithmic form will be the dependent variable for our econometric analysis) for three census years, 1841, 1871 and 1911. The overall picture is of quite modest changes but one or two relatively large shifts stand out. For example, chemicals moved steadily to North West, shipbuilding gravitated to the North and Scotland and away from South East and South West, vehicles expanded markedly in West Midlands but contracted in the southern regions. Textiles became even more concentrated in North West but declined in Scotland. There was not, however, a great deal of change in the localization of industry; those activities which were already heavily localized in 1841 such as shipbuilding and textiles became even more so while those like food, drink and tobacco remained regionally dispersed.

Table 2 reports Krugman's index of regional specialization for each pair of regions. This has a maximum of 2 in the case of complete specialization and a minimum of zero for complete similarity. It is noticeable that for some regional pairs there was a sharp change over time. For example, South West/North become much less alike in their industrial structure while at the other end of the spectrum Wales and

Yorkshire & Humberside became much more alike during 1841 to 1911. Overall, however, the average value of the regional specialization index varies only slightly, rising a little over 1841 to 1881 from 0.63 to 0.66 and then falling back to 0.61 in 1911. This is quite a contrast with developments in the United States where the average value of the regional specialization index rose from 0.59 in 1880 to 0.89 in 1914.[16]

The model of the location of industry outlined above points to interactions between industrial and regional characteristics as the key consideration. Accordingly, Tables 3 and 4 set out values of these variables which will be used in our econometric work. With regard to industry characteristics, we are reliant on the 1907 Census of Production and the input-output table for that year constructed by Mark Thomas.[17] The Census did not report establishment size but this can be inferred from the returns under the Factory and Workshop Act.

There was quite substantial variation of these characteristics across both industries and regions. For example, Table 3 shows that chemicals were intensive in the use of educated workers but textiles were not. Plant size was large in shipbuilding but small in food, drink & tobacco. The sectors with the biggest linkage effects were metal manufactures, leather and bricks which, interestingly, did not show up among the biggest movers in Table 1. In Table 4, as might be expected, East Anglia has much more agricultural employment than North West, London & South East has a much higher proportion of educated workers than any other region while coal abundance was characteristic of

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[16] Kim, "Expansion of Markets", Table 1.
[17] Thomas, "Input-Output Approach". Clearly, it is not ideal to assume that the input-output relationships remained unchanged throughout the period 1871-1911. We therefore undertook a robustness check on our results using preliminary estimates from an input-output table for 1851 which Charles Feinstein is preparing. In essence, all our econometric results reported below remained intact when these alternative data were used. We are very grateful to Charles Feinstein for sharing his estimates with us and letting us have the opportunity to make this test.

northern but not southern regions.[18] Market potential requires more detailed treatment which is provided in the next section.

The Evolution Of Market Potential

As has been explained, the notion of market potential is important for explanations of industrial location decisions based on New Economic Geography. To estimate market potential we follow the approach of David Keeble and his collaborators but modify the details to match the circumstances of an earlier transport era.[19] Market potential is defined as $P_i = \Sigma GDP_j d^{\eta}_{ij}$ where P_i is the market potential of region i and d_{ij} is the distance between region i and region j. η is traditionally set at -1. Own distance is approximated by the formula $d_{ii} = 0.333\sqrt{(\text{area of region}/\pi)}$. Thus market potential depends on a distance-deflated sum of neighboring regions' GDP and own GDP. In implementing this formula we included major trading partners overseas notably European countries, India and the United States with GDP converted into £ sterling at current exchange rates.[20]

The major problems in estimating market potential for this period lie in obtaining estimates of regional GDP for British regions and in the details of the distance deflation procedure. We have constructed estimates for regional GDP using a modified version of the methodology proposed by Geary and Stark.[21] Details are provided in the appendix. Inland distances between regions were based on the rail distance between the principal city in each region except where it was cheaper to

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[18] We measure coal abundance in terms of relative prices prevailing before the railway age which gives a clear indication of the traditional areas distinguished in standard accounts of nineteenth century industrial location.
[19] Keeble et al., "Regional Accessibility".
[20] These estimates were derived from Prados de la Escocura, "International Comparisons".
[21] Geary and Stark, "Examining Ireland's Post-Famine Economic Growth".

send goods by coastal shipping which remained a major component of British transport.[22] In that case sea miles were converted into rail-equivalent miles for the purpose of distance deflation using estimates of sea transport costs made by Yrjo Kaukiainen.[23] Rail-equivalent distances to foreign countries were estimated in similar fashion, see appendix.

Changes in market potential over time can result from either or both of a shift in the spatial distribution of GDP or in relative transport costs. In the period 1871-1911, developments in steamship technology and continuing improvement of railway productivity drove transport costs sharply down. However, as Table 5 reports, after about 1880 costs of sea transport fell by more than those of rail freight. The broad implication of this is that market potential rose relatively more in regions with good access to the sea, such as Scotland, compared with landlocked regions, such as the Midlands.

Table 6 reports estimates for regional market potential for the census years 1871 to 1911. In all cases, market potential was increasing appreciably at a time of economic growth at home and abroad. From the point of view of location decisions, it is relative market potential that matters. Here the obvious change was that East and West Midlands lost ground and London & South East gained. However, it should also be noted that Outer Britain (North, Scotland, Wales) also improved its position. The final column of Table 6 removes the effects of changes in relative transport costs by recalculating 1911 market potential using the rail-equivalent distances of 1871.[24] This does not entirely restore the

[22] Armstrong, "Role of Coastal Shipping", estimates that coastal shipping accounted for 59 per cent of internal freight ton-miles in 1910. Road haulage was negligible until after the First World War.
[23] Kaukiainen, "How the Price of Distance Declined".
[24] Thus sea miles are converted into rail miles using the 1871 relative transport costs and an 1871 rail mile is taken to be 1/0.782 of a 1911 rail mile. In terms of the exercise subsequently undertaken in Table 8 this scaling factor has no effect, it is only the change in relative costs that matters.

relative position of the landlocked Midlands, however, because regions like Scotland still gained more over the years 1871-1911 from the formidable growth of the United States.

Implications Of Falling Transport Costs

In this section we consider the implications of falling transport costs in the context of the Midelfart-Knarvik model of industrial location (see appendix for a further discussion on the model). The equation that we estimate is as follows:

$$\ln(s_i^k) = \alpha\ln(pop_i) + \beta\ln(man_i) + \Sigma(\beta[j]y[j]_i z[j]^k - \beta[j]\gamma[j]z[j]^k - \beta[j]k[j]y[j]_i)$$

where s_i^k is the share of industry k in region i, pop_i is the share of British population in region i, and man_i is the share of British manufacturing employment in region i; $y[j]_i$ is the level of the jth regional characteristic in region i; $z[j]^k$ is the industry k value of the industry characteristic paired with regional characteristic j. Finally, α, β, $\beta[j]$, $\gamma[j]$ and $k[j]$ are coefficients. For each census year from 1871 to 1911 this equation is estimated by OLS, pooling across industries.

The results are reported in Table 7. The intercept is followed by the two terms which pick up regional size effects, then the coefficients of the four regional characteristics, y[j], the six industry characteristics, z[j], and finally the six interaction variables, $\beta[j]$. The coefficients of interest are those on the interaction variables which capture the joint role of regional and industry characteristics in the location of industry. Transport costs play a role if the market potential interactions are a significant determinant of industrial location. If falling transport costs activate market potential considerations by entering the 'intermediate zone', then we should see market potential interactions becoming significant as time goes on.

Of the two size variables, manufacturing employment always has the right sign and is generally quite close to unity. In almost all cases, the coefficients of the regional characteristics have the expected negative signs but are usually statistically insignificant. With respect to the industry characteristics, the coefficients of the variables share of agricultural employment, educated population, and size of establishment have the expected negative signs and are significantly different from zero throughout.

Turning to the key interaction variables, the coefficients relating to interactions involving factor endowments have the correct (positive) signs; educated population*white collar workers, coal abundance*steam power use and agricultural employment*agricultural input use are significant virtually throughout. This confirms the importance of factor endowment variables in the location of industry. The traditional emphasis of the literature on coal endowments is also confirmed but other aspects of factor endowments seem to have mattered, namely, human capital and land. In fact, in terms of the overall proportion of variance in the dependent variable explained, the beta coefficients reported in Table 8 reveal that the relative importance of coal abundance was not as large as the other two. This suggests that there has been a tendency to over-simplification of the determinants of nineteenth century British industrial location.

With respect to the coefficients of the interaction variables involving market potential, market potential*intermediate input use and market potential*industry sale generally have the wrong sign but are always insignificant. Thus, there is no evidence that market potential mattered for location decisions either through upstream or downstream linkage effects even in 1911. This may indicate that transport costs were still too high for these considerations to have an impact on industrial location.[25] Market potential*size of establishment has the expected positive sign and is statistically significant but the coefficient decreases over time. This indicates that the pull of centrality for increasing returns industries was weakening over time as transport costs fell. However, as can be seen from Table 8, comparison of the relative importance of the market potential/size of establishment interaction variable with that of each of the three factor endowment variables shows that the pull of centrality of increasing returns industries was the single most powerful force. Nonetheless, taking all the factor endowment factors together the average beta coefficient sums to 0.159, higher than the market potential/size of establishment interaction variable at 0.118.

A glance back at Table 3 helps to make sense of these results. As was noted earlier, the sectors with the biggest linkage effects (bricks, metal manufactures, and leather) were not among the biggest movers in Table 1. The first two of these industries were the most intensive in the use of steam while leather was the most intensive user of agricultural inputs. In each case there was a strong factor endowment reason for their location which in a general equilibrium context dominated the attraction of market potential. These industries do indeed seem to epitomize the traditional argument that proximity to natural resources was crucial in nineteenth–century location decisions and this seems to have prevailed all the way through to World War I.[26]

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[25] Strictly speaking, these results could imply that they may already have been too low but given the finding by Midelfart-Knarvik et al., "Location of European Industry", pp. 36-7 that these effects *started* to have an impact in Europe only in the *1990s* we prefer the interpretation in the text.

[26] We have explored alternative econometric specifications to estimate our data set by pooling the five sets of cross-section data. Two sets of estimators that we considered are: the pooled least square estimator that represents the average of the within-groups and between-groups estimators; and least square estimators with region or sector specific effects or/and period specific effects that represent within-group estimators. Each of these leaves the regression results intact in all major details. All these results of alternative specifications are available from the authors upon request.

Overall, these results give much more support to explanations of the location of British industry in the period 1871 to 1911 based on factor endowments rather than New Economic Geography forces. It is, however, important to ask whether the impact of transport costs on market potential would have had much impact on regional shares of manufacturing employment according to these regression estimates. This can be discovered by using the counterfactual calculation of market potential based on 1871 distances reported in Table 6.

Table 9 is based on results obtained by re-estimating the equation omitting the insignificant market potential interaction variables and replacing the actual 1911 market potential variable with the value that would have been observed if transport costs had remained as in 1871 and then comparing the predictions for the dependent variable with those obtained using the original values for market potential on the right hand side. The general impression that emerges from this exercise is that the impact of transport costs improvements on location working through the remaining interaction of market potential and size of establishment is quite modest.

Looking at part a) of the table, the overall average change in a region's employment share of an industry is a little under 0.6 percentage points and inserting the counterfactual market potential with the transport costs change neutralized does not have much effect on the large shifts in employment shares highlighted earlier. Thus the North West's share of textiles and chemicals rose by 5.65 and 4.32 percentage points, respectively, but the changes in the predicted shares are only 0.30 and 0.24 percentage points. Similarly, shipbuilding in the North and Scotland gained 8.94 and 6.33 percentage points, respectively, but the changes in the predicted share are only 1.13 and 0.99 percentage points.

Turning to the impact of the counterfactual market potential on regions, the total changes in employment are on average about 2.4 per cent of regional employment and in no case is the change as much as 5 per cent. Table 1 shows that the biggest gain in regional share of all manufacturing employment between 1871 and 1911 is 2.37 percentage points in London & South East but the change in predicted share from inserting the counterfactual market potential variable is only 0.40 percentage points.

Growth Effects Of Steam–Powered Transport

In previous sections we have shown that the pattern of localization and specialization of British industry changed relatively little in the decades before World War I. We have also found that the main determinants of industrial location decisions were based on the interaction of regional factor endowments and industrial factor intensities. New Economic Geography forces appear to have been relatively weak with no role for the pull of centrality through linkage effects.

There was a role for market potential through the attraction that it offered to industries with large plant size. Improvements in steam technology reduced the costs of both water and railway transport quite appreciably between 1871 and 1911, as Table 5 reported. However, the impact that transport cost reductions had through the interaction of market potential and size of establishment was small - only very marginal shifts in industrial location can be attributed to this variable. And it should also be recognized that the coefficient on this variable was decreasing over time.

In the light of these results, it seems reasonable to argue that there is no reason to believe that estimates of the social savings from railway freight transport need to be revised on account of NEG–type externalities in the transport-using industries. Nor is there any strong case to argue that steam–powered transport improvements generated substantial TFP spillovers to add to their contribution to growth in the later decades of the nineteenth century. The dramatic relocations of industry that are such a striking feature of Chandler's account of the rise of mass production and mass distribution as railroads integrate the American domestic market are notable by their absence and so traditional neoclassical approaches to measuring the contribution of better transport to British economic growth are perfectly adequate.[27]

Conclusions

Our findings can be summarized in terms of answers to the four questions that we posed in the introduction.

First, the overriding impression is that patterns of the location of industry exhibited marked persistence. This is supported by the summary indices of localization and specialization that were reported in Tables 2 and 3, although as Table 1 shows there were changes in regional employment shares. In line with the traditional literature, our regression results suggest that factor endowments were the most important influence on the location of industry and this acted to anchor activities that were intensive in the use of natural resources, especially coal, in their existing locations. At the same time, the factor endowment hypothesis should not be oversimplified and human capital, in which London & South East was relatively well-endowed, was also an important influence on industrial location.

Second, market potential was affected by the changes in transport costs that were driving globalization forward in the period. In particular, sea transport costs fell relative to those of rail transport and GDP in important markets overseas, such as the United States, increased faster than in the UK. The implication of this was that market potential in

[27] Chandler, *Visible Hand*.

London & South East and in the regions of Outer Britain (North, Scotland, Wales) grew faster than in the Midlands, as was reported in Table 6. Thus, market potential in West Midlands fell from 69.1 per cent to 59.7 per cent of that in London & South East between 1871 and 1911 while over the same period in Scotland it rose from 67.5 per cent to 79.3 per cent of the London & South East level.

Third, the regressions in Table 7 provide evidence that the pull of centrality affected industrial location decisions through its attraction for industries with relatively large size of establishment. However, as transport costs fell over time the force of this attraction was weakening and industries seem to have become freer to locate on the basis of production rather than distribution costs. There is no evidence that market potential influenced location decisions through linkage effects. This probably reflects both the stronger pull of natural resource considerations and that in this pre-road-haulage era transport costs were still too high for these effects to materialize.

Fourth, Table 9 indicates that in the period falling transport costs had only weak effects on the location of industry in the period 1871 to 1911. This means that existing calculations of the impact of steam-powered transport on British economic growth probably do not need to be revised on account of productivity spillover effects.

Appendix

The regional GDP estimates that are required to calculate market potential have been constructed using a modified version of the methodology proposed by Frank Geary and Tom Stark. This uses data on employment structure (agriculture, industry, services) and sectoral wages together with estimates of UK output for each sector. It assumes that regional sectoral productivity relative to the UK average is reflected in regional sectoral wages relative to the UK average.

UK GDP is defined as

$$Y_{UK} = \Sigma Y_i$$

where Y_i is GDP of region i which in turn is defined as

$$Y_i = \Sigma y_{ij} L_{ij}$$

where y_{ij} is average value-added per worker in region i in sector j and L_{ij} is the corresponding number of workers.

Then assume that

$$Y_i = \Sigma[y_j \beta_j (w_{ij}/w_j)] L_{ij}$$

where y_j is UK output per worker in sector j, w_{ij} is the wage paid in region i in sector j and w_j is the national average wage in sector j. β is a scalar which preserves the relative regional differences but scales the absolute levels so that regional totals for each sector sum to the known UK total.

The resulting pattern of GDP in these years 1871 to 1911 is, however, rather different from that of the income tax assessments. At this time income tax was levied essentially on non-wage income. Accordingly it seems better to use the Geary-Stark method to allocate wage incomes across regions but to use the tax data to allocate non-wage incomes. This is the basis of the regional income estimates that have been used to construct the estimates of market potential reported in Table 6. Full details of the sources used to implement this approach can be found elsewhere.[28]

Data on rail distances was taken from *Bradshaw's Railway Guide*. The length of sea journeys was obtained from *www:dataloy.com/newwebsite/index.php*. These were converted into rail equivalent miles using estimates of the costs of sea transport, taking account both of terminal charges and costs per mile, and converting it into a rail equivalent based on the average charge per ton-mile of rail freight. Where foreign trade was concerned an allowance was also made for the cost-equivalent of tariffs. Full details can be found elsewhere.[29]

[28] Crafts, "Regional GDP".
[29] Crafts, "Market Potential".

The Midelfart-Knarvik et al. expanded model,

$$\ln(s_i^k) = \alpha\ln(pop_i) + \beta\ln(man_i) + \Sigma(\beta[j]y[j]_i z[j]^k - \beta[j]\gamma[j]z[j]^k - \beta[j]k[j]y[j]_i)$$

is derived from their basic model that is specified as

$$\ln(s_i^k) = \alpha\ln(pop_i) + \beta\ln(man_i) + \Sigma(\beta[j]y[j]_i - \gamma[j]z[j]^k - k[j])$$

where s_i^k is the share of industry k in region i, pop_i is the share of British population in region i, and man_i is the share of British manufacturing employment in region i; $y[j]_i$ is the level of the jth regional characteristic in region i; $z[j]^k$ is the industry k value of the industry characteristic paired with regional characteristic j. Finally, α, β, $\beta[j]$, $\gamma[j]$ and k[j] are coefficients.

As in all location theories, in this model of industry location regions and industry characteristics interact to determine the location of industry. Regions are heterogeneous in various characteristics such as endowments of natural resources and skilled labor and proximity to markets. Similarly, industries differ in their various attributes such as the intensity of use of production factors like natural resources and skilled labor, and their reliance on intermediate inputs. Intuitively, one would then expect that, in an integrated market economy, firms' profit motive would lead to a regional distribution of industries that is in someway determined by the interactions of the various regional and industry characteristics. The rationale for the emphasis on the interaction of industry and country characteristics lies in the general equilibrium nature of the system. Other things equal, every industry may want to locate in a region that is relatively well endowed with coal but a scenario of all industries located in a coal-rich region cannot prevail in equilibrium. Hence only industries that are relatively intensive users of steam power end up in regions that are relatively rich in coal. Therefore, the model's predictions of industry location entail only the interactions of region and industry characteristics.

What the model says is that after controlling for regional size effects (via the first two variables) i.e. the hypothesis that *ceteris paribus*, a larger location is likely to have a higher share of any industry, the pattern of industry is shaped by the interactions between regional and industry characteristics. The interaction forces are represented by the terms in the summation. For a more specific discussion of these interaction forces, we reproduce here Midelfart-Knarvik et al.'s illustration of the meaning of their model by means of a specific example, say, skilled labor. So $z[skilled\ labor]^k$ is skilled-labor intensity of industry k and $y[skilled\ labor]_i$ is skilled-labor abundance of region i. The following interpretation can then be given to the model: A) There exists an industry with a *cut-off* level of skilled-labor intensity *k[skilled labor]* such that its location is independent of regional skilled-labor abundance; B) There exists a *cut-off* level of skilled-labor abundance γ*[skilled labor]* such that the region's share of any industry is independent of the skilled-labor intensity of the industry; and C) If $\beta[skilled\ labor] > 0$, then industries with skilled-labor intensity greater than the *cut-off* point, i.e. *k[skilled labor]* will be induced to locate near regions with skilled-labor abundance greater than the *cut-off* point, i.e. γ*[skilled labor]* and away from regions with skilled-labor abundance less than this *cut-off* point.

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Table 1. Regional Shares of Manufacturing Employment (%)

1841	London & S East	East Anglia	South West	West Midlands	East Midlands	North West	Yorks & Humbs	North	Wales	Scotland
Food, Drink & Tobacco	33.57	5.33	10.74	7.23	7.13	8.94	6.47	5.17	3.14	12.28
Chemicals	34.41	2.72	7.91	7.34	4.86	14.91	7.62	7.28	3.91	9.04
Metal Manufacture	17.15	3.62	9.64	16.22	5.20	9.62	6.89	7.67	10.34	13.65
Mechanical Engineering	14.07	2.19	4.48	15.79	6.33	19.76	16.78	5.50	2.02	13.08
Instrument Engineering	39.52	3.09	6.61	11.98	4.07	16.71	3.76	3.62	2.87	7.83
Shipbuilding	27.88	3.36	13.19	1.56	1.18	9.32	3.17	19.68	5.59	15.06
Vehicles	34.85	7.37	8.46	12.31	9.98	8.89	6.38	3.98	3.01	4.77
Metal Goods	15.06	0.82	3.93	33.51	4.48	8.19	24.04	2.66	1.79	5.52
Textiles	6.24	1.18	4.39	3.13	8.36	35.10	16.95	2.04	1.01	21.59
Leather	33.12	4.34	10.09	11.37	6.55	8.04	7.45	5.73	3.85	9.45
Clothing & Footwear	28.80	4.46	12.14	7.58	7.42	10.66	6.31	4.99	4.20	13.44
Bricks, Pottery	13.70	2.79	3.18	45.28	6.48	7.71	5.63	7.34	1.67	6.20
Timber, Furniture	34.27	3.86	10.94	8.19	4.78	10.52	4.87	4.88	3.71	13.98
Paper, Printing	48.03	2.49	6.25	5.00	3.26	11.36	4.84	3.70	1.87	13.20
Other Manufacturing	32.95	1.23	5.51	33.34	2.10	7.74	7.62	2.18	0.45	6.87
All Manufacturing	20.02	2.98	7.92	8.71	7.09	19.45	10.98	4.22	3.04	15.58

1871	London & S East	East Anglia	South West	West Midlands	East Midlands	North West	Yorks & Humbs	North	Wales	Scotland
Food, Drink & Tobacco	32.17	4.12	9.27	7.90	6.20	11.92	7.63	5.25	3.71	11.82
Chemicals	27.98	2.11	4.94	8.09	4.09	18.43	10.80	9.31	3.42	10.82
Metal Manufacture	11.55	1.90	4.84	19.30	4.33	12.59	10.65	11.22	10.30	13.33
Mechanical Engineering	16.13	1.38	3.99	12.79	5.25	20.92	12.21	10.10	2.88	14.35
Instrument Engineering	35.94	2.17	5.36	20.10	3.61	13.61	5.53	3.39	2.32	7.96
Shipbuilding	19.62	1.82	7.68	1.07	1.00	12.69	3.50	21.34	4.82	26.47
Vehicles	31.48	5.77	8.80	12.54	9.08	12.96	7.97	3.31	2.73	5.37
Metal Goods	14.74	0.83	2.64	39.36	2.57	5.71	25.88	2.40	1.55	4.33
Textiles	6.16	0.97	3.32	2.82	8.00	38.84	20.90	1.29	0.83	16.88
Leather	34.89	5.13	8.40	13.58	6.07	8.16	9.61	4.01	2.60	7.56
Clothing & Footwear	33.20	4.19	11.04	7.37	8.38	10.71	6.43	4.60	4.05	10.05
Bricks, Pottery	13.11	2.09	3.67	41.12	4.47	9.81	7.55	9.20	1.89	7.09
Timber, Furniture	39.40	2.68	7.87	8.34	4.18	11.44	6.61	4.90	2.73	11.87
Paper, Printing	46.31	2.30	5.58	5.09	3.34	11.73	5.29	3.45	1.61	15.30
Other Manufacturing	37.94	0.83	3.13	23.44	8.34	8.52	5.36	1.30	0.55	10.60
All Manufacturing	21.44	2.51	6.49	9.72	6.59	19.92	12.30	4.85	3.27	12.93

1911	London & S East	East Anglia	South West	West Midlands	East Midlands	North West	Yorks & Humb	North	Wales	Scotland
Food, Drink & Tobacco	32.31	3.04	7.20	7.20	6.26	14.52	8.15	5.05	4.51	11.73
Chemicals	29.82	1.77	4.38	5.83	3.51	22.75	10.68	7.30	3.10	10.85
Metal Manufacture	10.35	1.34	3.15	16.97	6.27	12.66	12.62	10.65	10.06	15.93
Mechanical Engineering	16.96	1.40	4.23	8.30	7.59	22.01	12.13	9.32	2.88	15.17
Instrument Engineering	44.52	1.77	4.08	12.88	4.70	10.46	6.66	3.49	2.78	8.66
Electrical Engineering	41.44	1.29	3.02	10.61	4.39	17.69	5.81	5.85	3.05	6.85
Shipbuilding	14.17	0.88	4.32	0.36	0.61	10.20	2.90	30.28	3.47	32.80
Vehicles	27.89	2.16	6.52	27.67	7.74	10.18	7.05	2.52	2.74	5.49
Metal Goods	17.24	0.89	2.97	37.99	2.59	9.94	17.06	3.03	2.33	5.98
Textiles	6.45	0.69	2.10	2.44	8.40	44.49	20.32	1.24	0.94	12.92
Leather	39.14	3.44	5.64	15.88	6.17	10.07	9.09	2.56	1.75	6.25
Clothing & Footwear	33.87	2.87	7.98	6.09	11.08	13.42	8.25	3.75	3.87	8.84
Bricks, Pottery	16.28	1.53	3.38	39.03	5.57	10.53	8.77	4.95	2.99	6.97
Timber, Furniture	38.40	2.10	6.18	7.46	5.23	13.81	8.23	3.97	2.55	12.07
Paper, Printing	44.65	1.80	5.55	5.84	4.82	13.61	6.58	2.94	1.81	12.40
Other Manufacturing	35.07	1.06	3.76	15.73	6.13	20.13	4.01	1.60	0.80	12.11
All Manufacturing	23.81	1.85	4.97	9.77	7.15	20.69	11.57	4.98	3.37	11.82

Source: derived from Lee, *British Regional Employment*.

Table 2. Index of Regional Specialization in Manufacturing, 1841-1911

	1841	***1851***	***1861***	***1871***	***1881***	***1891***	***1901***	***1911***
SE/EA	0.20	0.22	0.23	0.24	0.25	0.28	0.28	0.25
SE/SW	0.28	0.34	0.26	0.25	0.27	0.27	0.25	0.23
SE/WM	0.67	0.72	0.74	0.77	0.76	0.76	0.76	0.79
SE/EM	0.66	0.71	0.64	0.59	0.56	0.53	0.52	0.57
SE/NW	1.12	1.06	1.05	1.04	1.00	0.97	0.87	0.88
SE/YH	1.04	1.04	1.04	1.02	1.00	0.95	0.83	0.86
SE/N	0.41	0.41	0.50	0.65	0.64	0.69	0.73	0.72
SE/W	0.39	0.51	0.51	0.55	0.53	0.50	0.43	0.48
SE/SC	0.81	0.79	0.71	0.77	0.72	0.68	0.62	0.68
SE Average	***0.62***	***0.64***	***0.63***	***0.65***	***0.64***	***0.63***	***0.59***	***0.61***
EA/SE	0.20	0.22	0.23	0.24	0.25	0.28	0.28	0.25
EA/SW	0.18	0.20	0.16	0.13	0.13	0.13	0.11	0.12
EA/WM	0.63	0.69	0.75	0.78	0.77	0.78	0.76	0.80
EA/EM	0.61	0.65	0.64	0.53	0.47	0.42	0.36	0.44
EA/NW	1.07	1.03	0.99	0.98	0.91	0.92	0.82	0.82
EA/YH	1.02	0.99	0.97	0.96	0.91	0.89	0.80	0.78
EA/N	0.34	0.36	0.50	0.64	0.63	0.70	0.72	0.70
EA/W	0.36	0.44	0.53	0.55	0.51	0.49	0.42	0.44
EA/SC	0.75	0.73	0.66	0.71	0.65	0.64	0.59	0.57
EA Average	***0.57***	***0.59***	***0.60***	***0.61***	***0.58***	***0.58***	***0.54***	***0.55***
SW/SE	0.28	0.34	0.26	0.25	0.27	0.27	0.25	0.23
SW/EA	0.18	0.20	0.16	0.13	0.13	0.13	0.11	0.12
SW/WM	0.66	0.70	0.72	0.79	0.80	0.80	0.78	0.80
SW/EM	0.52	0.55	0.53	0.46	0.43	0.36	0.33	0.43
SW/NW	0.94	0.90	0.93	0.90	0.86	0.93	0.78	0.79
SW/YH	0.89	0.85	0.88	0.88	0.87	0.84	0.74	0.75
SW/N	0.27	0.34	0.44	0.64	0.65	0.69	0.71	0.69
SW/W	0.34	0.41	0.45	0.53	0.52	0.48	0.40	0.43
SW/SC	0.63	0.61	0.54	0.62	0.60	0.58	0.52	0.56
SW Average	***0.52***	***0.54***	***0.55***	***0.58***	***0.57***	***0.56***	***0.51***	***0.54***
WM/SE	0.67	0.72	0.74	0.77	0.76	0.76	0.76	0.79
WM/EA	0.63	0.69	0.75	0.78	0.77	0.78	0.76	0.80
WM/SW	0.66	0.70	0.72	0.79	0.80	0.80	0.78	0.80
WM/EM	0.73	0.79	0.82	0.83	0.80	0.83	0.80	0.83
WM/NW	1.08	1.02	1.03	1.02	0.98	0.98	0.88	0.90
WM/YH	0.88	0.92	0.87	0.86	0.83	0.82	0.71	0.72
WM/N	0.48	0.47	0.44	0.46	0.54	0.56	0.59	0.66
WM/W	0.58	0.51	0.55	0.58	0.58	0.57	0.60	0.65
WM/SC	0.79	0.78	0.75	0.75	0.74	0.75	0.73	0.75
WM Average	***0.72***	***0.73***	***0.74***	***0.76***	***0.76***	***0.76***	***0.74***	***0.77***
EM/SE	0.66	0.71	0.64	0.59	0.56	0.53	0.52	0.57
EM/EA	0.61	0.65	0.64	0.53	0.47	0.42	0.36	0.44
EM/SW	0.52	0.55	0.53	0.46	0.43	0.36	0.33	0.43
EM/WM	0.73	0.79	0.82	0.83	0.80	0.83	0.80	0.83

EM/NW	0.49	0.41	0.45	0.49	0.48	0.54	0.51	0.52
EM/YH	0.41	0.40	0.43	0.47	0.47	0.50	0.45	0.44
EM/N	0.53	0.62	0.65	0.76	0.74	0.77	0.74	0.77
EM/W	0.67	0.72	0.68	0.63	0.61	0.59	0.54	0.64
EM/SC	0.23	0.19	0.21	0.28	0.30	0.40	0.37	0.40
EM Average	***0.54***	***0.56***	***0.56***	***0.56***	***0.54***	***0.55***	***0.51***	***0.56***
NW/SE	1.12	1.06	1.05	1.04	1.00	0.97	0.87	0.88
NW/EA	1.07	1.03	0.99	0.98	0.91	0.92	0.82	0.82
NW/SW	0.94	0.90	0.93	0.90	0.86	0.93	0.78	0.79
NW/WM	1.08	1.02	1.03	1.02	0.98	0.98	0.88	0.90
NW/EM	0.49	0.41	0.45	0.49	0.48	0.54	0.51	0.52
NW/YH	0.22	0.14	0.18	0.19	0.17	0.20	0.21	0.23
NW/N	0.98	0.96	1.00	1.02	0.97	0.94	0.84	0.83
NW/W	1.11	1.08	1.07	1.04	0.97	0.93	0.83	0.87
NW/SC	0.34	0.32	0.42	0.40	0.44	0.45	0.45	0.47
NW Average	***0.82***	***0.77***	***0.79***	***0.79***	***0.75***	***0.76***	***0.69***	***0.70***
YH/SE	1.04	1.04	1.04	1.02	1.00	0.95	0.83	0.86
YH/EA	1.02	0.99	0.97	0.96	0.91	0.89	0.80	0.78
YH/SW	0.89	0.85	0.88	0.88	0.87	0.84	0.74	0.75
YH/WM	0.88	0.92	0.87	0.86	0.83	0.82	0.71	0.72
YH/EM	0.41	0.40	0.43	0.47	0.47	0.50	0.45	0.44
YH/NW	0.22	0.14	0.18	0.19	0.17	0.20	0.21	0.23
YH/N	0.91	0.92	0.95	0.97	0.94	0.93	0.83	0.87
YH/W	1.05	1.02	1.02	0.99	0.95	0.88	0.74	0.74
YH/SC	0.29	0.28	0.39	0.36	0.42	0.41	0.39	0.39
YH Average	***0.75***	***0.73***	***0.75***	***0.74***	***0.73***	***0.71***	***0.63***	***0.64***
N/SE	0.41	0.41	0.50	0.65	0.64	0.69	0.73	0.72
N/EA	0.34	0.36	0.50	0.64	0.63	0.70	0.72	0.70
N/SW	0.27	0.34	0.44	0.64	0.65	0.69	0.71	0.69
N/WM	0.48	0.47	0.44	0.46	0.54	0.56	0.59	0.66
N/EM	0.53	0.62	0.65	0.76	0.74	0.77	0.74	0.77
N/NW	0.98	0.96	1.00	1.02	0.97	0.94	0.84	0.83
N/YH	0.91	0.92	0.95	0.97	0.94	0.89	0.74	0.73
N/W	0.33	0.35	0.34	0.32	0.32	0.40	0.41	0.42
N/SC	0.67	0.68	0.62	0.66	0.60	0.56	0.52	0.45
N Average	***0.55***	***0.57***	***0.60***	***0.68***	***0.67***	***0.69***	***0.67***	***0.66***
W/SE	0.39	0.51	0.51	0.55	0.53	0.50	0.43	0.48
W/EA	0.36	0.44	0.53	0.55	0.51	0.49	0.42	0.44
W/SW	0.34	0.41	0.45	0.53	0.52	0.48	0.40	0.43
W/WM	0.58	0.51	0.55	0.58	0.58	0.57	0.60	0.65
W/EM	0.67	0.72	0.68	0.63	0.61	0.59	0.54	0.64
W/NW	1.11	1.08	1.07	1.04	0.97	0.93	0.83	0.87
W/YH	1.05	1.02	1.02	0.99	0.95	0.88	0.74	0.74
W/N	0.33	0.35	0.34	0.32	0.32	0.40	0.41	0.42
W/SC	0.80	0.79	0.71	0.73	0.66	0.61	0.54	0.59
W Average	***0.63***	***0.65***	***0.65***	***0.66***	***0.63***	***0.61***	***0.55***	***0.58***
SC/SE	0.81	0.79	0.71	0.77	0.72	0.68	0.62	0.68
SC/EA	0.75	0.73	0.66	0.71	0.65	0.64	0.59	0.57

SC/SW	0.63	0.61	0.54	0.62	0.60	0.58	0.52	0.56
SC/WM	0.79	0.78	0.75	0.75	0.74	0.75	0.73	0.75
SC/EM	0.23	0.19	0.21	0.28	0.30	0.40	0.37	0.40
SC/NW	0.34	0.32	0.42	0.40	0.44	0.45	0.45	0.47
SC/YH	0.29	0.28	0.39	0.36	0.42	0.41	0.39	0.39
SC/N	0.67	0.68	0.62	0.66	0.60	0.56	0.52	0.45
SC/W	0.80	0.79	0.71	0.73	0.66	0.61	0.54	0.59
SC Average	***0.59***	***0.57***	***0.56***	***0.59***	***0.57***	***0.56***	***0.53***	***0.54***
All Average	***0.63***	***0.64***	***0.64***	***0.66***	***0.64***	***0.64***	***0.59***	***0.61***

Source: derived from Lee, *British Regional Employment* using 2-digit classification based on the formula $SI_{jk} = \Sigma |E_{ij}/E_j - E_{ik}/E_k|$ where E_{ij} is the level of employment in industry i in region j, E_j is total employment in region j and similarly for region k.

Table 3. Industry Characteristics, 1907

	White Collar	*Steam Use*	*Plant Size*	*Intermed. Input Use*	*Agricult. Input Use*	*Sales to Industry*
Food, Drink & Tobacco	13.4	0.94	15.0	63.0	17.4	18.2
Chemicals	13.8	2.44	35.9	71.0	0	31.8
Metal Manufactures	5.7	7.10	67.6	79.3	0	60.4
Mechanical Engineering	8.5	2.50	50.3	51.6	0	15.0
Instrument Engineering	12.2	2.50	23.0	51.6	0	15.0
Electrical Engineering	8.5	2.50	64.8	51.6	0	15.0
Shipbuilding	5.0	1.96	164.6	57.1	0	37.6
Vehicles	5.2	1.51	62.4	52.7	0	49.8
Metal Goods	7.8	1.57	32.6	54.4	0	13.2
Textiles	3.4	5.74	155.3	71.7	1.2	44.7
Leather	11.6	0.69	28.9	78.4	17.8	55.2
Clothing & Footwear	10.3	0.45	72.0	55.3	0	4.9
Bricks, Pottery	6.1	8.02	39.7	39.0	0	92.7
Timber, Furniture	10.1	2.54	22.8	53.9	1.5	56.2
Paper, Publishing	11.8	2.99	21.9	45.2	0.5	29.2
Other Manufacturing	10.1	2.02	27.3	52.9	0	35.0

Sources:

White Collar is the percentage of employees classified by the Census of Production as "Administrative, Clerical and Technical".
Steam Use is steam horsepower per £000 of gross output according to the Census of Production.
Plant size is based on employment per establishment based on returns under the Factory & Workshop Act, *Parliamentary Papers*, 1909, vol. LXXIX.
Input-output data derived from Thomas, "Input-Output Approach" and expressed as a percentage of gross output.

Table 4. Regional Characteristics, 1871-1911

	Agricultural Employment 1871	***Educated Population 1871***	***Agricultural Employment 1881***	***Educated Population 1881***
London & South East	9.7	9.5	8.9	9.2
East Anglia	35.0	6.1	33.3	5.1
South West	22.1	6.7	21.0	5.7
West Midlands	13.3	5.8	11.5	5.5
East Midlands	21.7	5.1	18.1	4.8
North West	5.8	6.6	4.6	6.2
Yorkshire & Humb.	8.8	5.0	7.6	5.1
North	14.2	5.8	11.9	5.1
Wales	20.1	5.4	17.1	4.5
Scotland	22.2	5.3	16.7	7.6
	1891	***1891***	***1901***	***1901***
London & South East	7.7	11.7	5.3	10.4
East Anglia	31.7	6.9	27.4	6.8
South West	18.3	7.9	15.6	7.8
West Midlands	9.8	7.2	7.7	8.0
East Midlands	15.5	6.1	12.3	6.5
North West	4.1	7.4	3.3	8.3
Yorkshire & Humb.	6.2	6.3	5.0	7.2
North	9.9	6.6	8.0	7.0
Wales	14.1	6.4	12.1	6.8
Scotland	14.0	8.2	11.5	9.1
	1911	***1911***	***Coal Prices***	
London & South East	4.9	12.4	252	
East Anglia	27.4	6.8	246	
South West	15.1	7.8	255	
West Midlands	7.3	8.0	90	
East Midlands	11.4	6.5	102	
North West	3.0	8.3	99	
Yorkshire & Humb.	4.6	7.2	90	
North	7.3	7.0	68	
Wales	10.4	6.8	126	
Scotland	10.6	9.1	91	

Sources:

Agricultural employment, measured as a percentage of total employment, from Lee, *British Regional Employment*.

Educated population, measured as a percentage of total employment, based on employment in categories III (Professional Occupations and their Subordinate Services) and V (Merchants, Banking, Insurance, Clerks) from the Census of Population.

Coal Prices based on prices paid by Poor Law Unions, *Parliamentary Papers*, 1843, vol. XLV.

Table 5. Real Transport Costs, 1871-1911

	Coastal Shipping		***Rail***
1872/4	100.0	1871	100.0
1879/80	109.2	1880	99.1
1892/3	84.0	1890	95.2
1898/9	80.4	1900	90.3
1911/13	53.3	1911	78.2

Sources: coastal shipping based on a distance of 400 miles from Kaukiainen, "Price of Distance"; rail based on average rates per ton per mile from Cain, "Private Enterprise" deflated using GDP deflator.

Table 6. Market Potential (£ mn)

	1871	*1881*	*1891*	*1901*	*1911*	*1911 at 1871 distances*
London & South East	44.3	54.6	73.4	113.9	148.1	85.6
East Anglia	31.0	37.9	52.3	80.5	108.1	60.8
South West	35.2	44.3	60.1	93.9	124.0	65.8
West Midlands	30.6	36.9	46.5	67.5	88.4	56.7
East Midlands	28.8	34.5	43.7	62.9	82.8	53.6
North West	40.6	50.1	65.7	97.1	125.4	75.8
Yorkshire & Humbs	32.8	40.4	52.4	78.7	102.4	62.2
North	31.4	40.7	56.9	91.1	119.6	57.6
Wales	33.7	43.7	59.8	94.0	125.9	65.1
Scotland	29.9	39.6	55.5	89.4	117.5	60.2

Source: Crafts, "Market Potential".

Table 7. Location of British Industry Regressions, 1871-1911

	1871	*1881*	*1891*	*1901*	*1911*
Constant	2.5291	–1.1308	2.3891	1.7668	2.3529
	(2.063)	(1.963)	(3.224)	(1.910)	(2.027)
Population	0.4926	1.8630*	–0.3991	–0.1754	–1.0839
	(0.416)	(1.077)	(3.863)	(0.929)	(1.191)
Manufacturing Employment	0.8147**	0.4685**	0.8476	0.8664**	0.9834**
	(0.285)	(0.233)	(0.993)	(0.280)	(0.294)
% Agricultural Employment	–0.0232**	–0.0037	–0.0329	–0.0150	–0.0380
	(0.014)	(0.020)	(0.060)	(0.021)	(0.034)
% Educated Population	–0.2509	–0.4042*	–0.1590	–0.2489	–0.0696
	(0.227)	(0.252)	(0.560)	(0.227)	(0.253)
Coal Abundance	–0.0874*	–0.1810**	–0.0507	–0.0486	–0.0084
	(0.063)	(0.086)	(0.188)	(0.058)	(0.062)
Market Potential	–0.0845*	–0.0512	–0.0101	0.0001	0.0061
	(0.055)	(0.052)	(0.055)	(0.018)	(0.014)
Agricultural Input Use	–0.0233**	–0.0225**	–0.0197**	–0.0216**	–0.0182**
	(0.012)	(0.011)	(0.011)	(0.010)	(0.010)
% White Collar Workers	–0.3138**	–0.1797**	–0.3439**	–0.3446**	–0.3327**
	(0.115)	(0.100)	(0.117)	(0.116)	(0.118)
Steam Power Use	0.0873	0.1775	0.1880	0.2002	0.2363
	(0.109)	(0.121)	(0.110)	(0.121)	(0.121)
Intermediate Input Use	0.0315	0.0300	0.0388	0.0346	0.0358
	(0.026)	(0.027)	(0.029)	(0.026)	(0.027
Industry Sale	–0.0026	0.0077	0.0001	0.0035	0.0030
	(0.014)	(0.014)	(0.017)	(0.015)	(0.016)
Size of Establishment	–0.0217*	–0.0185*	–0.0326**	–0.0327**	–0.0337**
	(0.015)	(0.014)	(0.014)	(0.013)	(0.014)
Agricultural Employment* Agricultural Input Use	0.0014**	0.0015**	0.0015**	0.0022**	0.0019**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

Educated Population* White Collar Workers	0.0525** (0.017)	0.0327** (0.015)	0.0459** (0.015)	0.0489** (0.016)	0.0402** (0.014)
Coal Abundance* Steam Power Use	0.0079 (0.009)	0.0156** (0.009)	0.0159** (0.008)	0.0153** (0.009)	0.0179** (0.009)
Market Potential* Intermediate Input Use	–0.0008 (0.001)	–0.0006 (0.001)	–0.0006 (0.0005)	–0.0004 (0.0003)	–0.0003 (0.0002)
Market Potential* Industry Sale	0.0001 (0.0004)	–0.0001 (0.0003)	0.00001 (0.0003)	–0.0001 (0.0002)	–0.00004 (0.00013)
Market Potential* Size of Establishment	0.0006* (0.0004)	0.0004* (0.0003)	0.0005** (0.0002)	0.0003** (0.0001)	0.0003** (0.0001)
Observations	150	160	160	160	160
Adj. R^2	0.57	0.59	0.63	0.66	0.65

Notes: With heteroskedasticity-corrected standard errors in parenthesis.
* indicates significance at 10% level. ** indicates significance at 5% level.

Table 8. Beta Coefficients

Variables	***1871***	***1881***	***1891***	***1901***	***1911***	***Average***
Market Potential* Size of establishment	0.0975	0.0805	0.1319	0.1416	0.1432	0.118
Educated Population* White Collar Workers	0.1179	0.0694	0.1127	0.1180	0.1121	0.106
Coal Abundance*Steam Power Use	0.0231	0.0408	0.0412	0.0419	0.0475	0.038
Share of Agricultural Employment*Agricultural Input Use	0.0168	0.0140	0.0128	0.0163	0.0134	0.014
HO factors as a whole	*0.1578*	*0.1242*	*0.1667*	*0.1762*	*0.1730*	*0.159*

Beta coefficients are adjusted regression coefficients, which are all in the same unit (and thus are comparable). They are defined as: $beta(i) = \frac{s_{xi}}{s_y}\hat{\beta}_i$, where s_{xi} and s_y are, respectively the sample standard deviations of x_i and y.

Table 9. Counterfactual Employment in 1911

a) Average Absolute Change in Employment Shares (percentage points)

Food Drink & Tobacco	0.470
Chemicals	0.721
Metal Manufacture	0.378
Mechanical Engineering	0.218
Instrument Engineering	0.438
Electrical Engineering	0.182
Shipbuilding	1.361
Vehicles	0.343
Metal Goods	0.592
Textiles	1.182
Leather	0.342
Clothing & Footwear	0.540
Bricks, Pottery	0.681
Timber, Furniture	0.680
Paper, Printing	0.534
Other Manufacturing	0.563

b) Change in Manufacturing Employment and All Manufacturing Employment Share

	Employment	Share (percentage points)
London & South East	+28888	+0.40
East Anglia	− 1269	−0.02
South West	+17030	+0.23
West Midlands	− 3589	−0.05
East Midlands	−21722	−0.32
North West	+ 9156	+0.13
Yorkshire & Humberside	−14456	−0.21
North	+ 5914	+0.08
Wales	+11679	+0.16
Scotland	+25778	+0.35

Source: counterfactual employment is based on re-estimating the equation of Table 7 with market potential*intermediate input use and market potential*industry sale omitted and employing the market potential estimates to 1911 using 1871 distances reported in Table 6.

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