

Input-Output and Regional General Equilibrium and Dynamic General Equilibrium Models of Humber and Hull Sub Regions of East Yorkshire in England

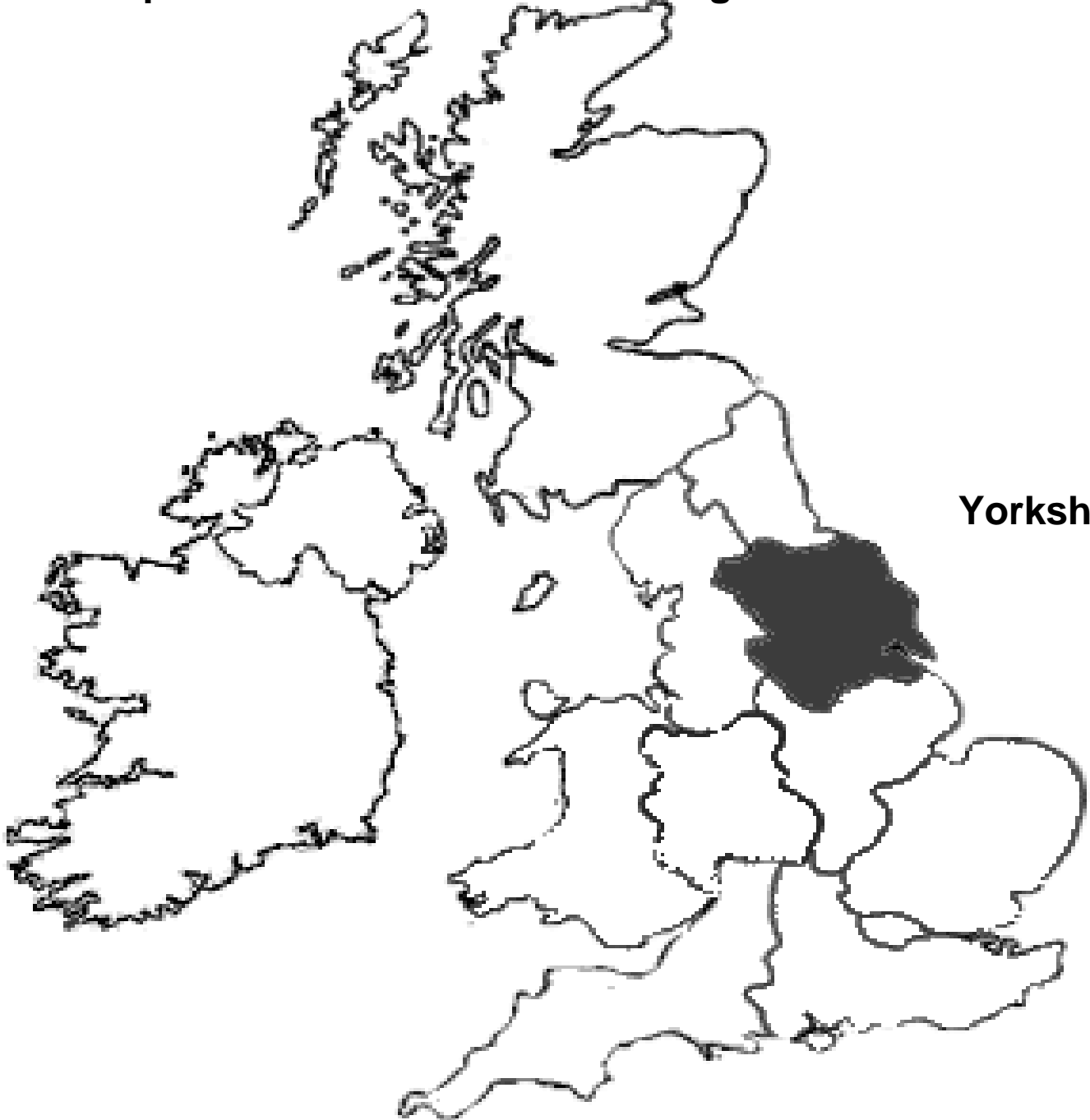
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Regional Differences in Economic Indicators in UK, 2004

| | GVADEDED | Perhead | Population | pop-gr91-03 | Labforce | EmplRate | Earning_M | Earning_F | Perc W&S |
|--------------------------|----------|---------|------------|-------------|----------|----------|-----------|-----------|----------|
| North East | 34,188 | 13,433 | 2,545.1 | -1.8 | 1,063 | 69.7 | 488.5 | 391.0 | 66 |
| North West | 101,996 | 14,940 | 6,827.2 | -0.6 | 2,987 | 72.9 | 532.3 | 409.6 | 68 |
| Yorkshire and the Humber | 75,219 | 14,928 | 5,038.8 | 1.5 | 2,246 | 73.8 | 513.0 | 395.5 | 67 |
| East Midlands | 65,770 | 15,368 | 4,279.7 | 6.0 | 1,965 | 76.0 | 531.2 | 400.4 | 71 |
| West Midlands | 81,745 | 15,325 | 5,334.0 | 1.7 | 2,383 | 74.6 | 518.9 | 402.0 | 67 |
| East | 100,307 | 18,267 | 5,491.3 | 6.7 | 2,611 | 78.6 | 609.7 | 443.1 | 70 |
| London | 164,961 | 22,204 | 7,429.2 | 8.2 | 3,334 | 69.3 | 731.4 | 556.1 | 71 |
| South East | 158,187 | 19,505 | 8,110.2 | 5.9 | 3,892 | 78.6 | 644.4 | 465.1 | 67 |
| South West | 78,650 | 15,611 | 5,038.2 | 6.6 | 2,341 | 78.9 | 535.0 | 402.2 | 64 |
| England | 861,022 | 17,188 | 50,093.8 | 4.1 | 22,823 | 74.8 | 581.8 | 441.5 | 68 |
| Wales | 39,243 | 13,292 | 2,952.5 | 2.3 | 1,239 | 70.8 | 499.5 | 402.0 | 64 |
| Scotland | 82,050 | 16,157 | 5,078.4 | -0.5 | 2,331 | 74.6 | 522.0 | 425.8 | 68 |
| Northern Ireland | 23,058 | 13,482 | 1,710.3 | 5.9 | 713 | 68.0 | 487.1 | 402.3 | 64 |

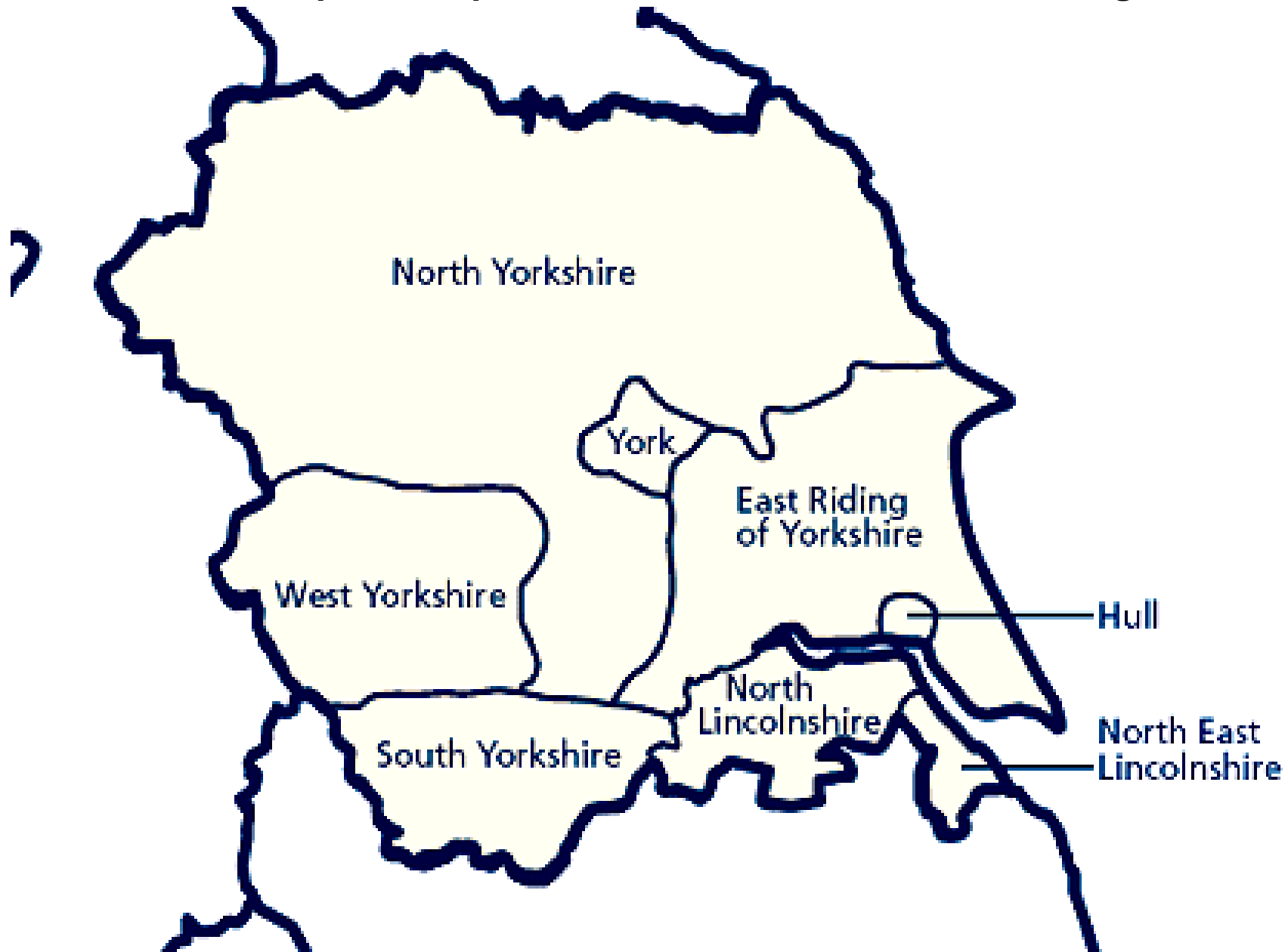
Source: Compiled from the Office of National Statistics: Regional Data Base (www.statistics.gov.uk)

Map 1: Yorkshire and Humber Region in the United Kingdom



Yorkshire and Humber

Map 2: Composition of Yorkshire and Humber Region





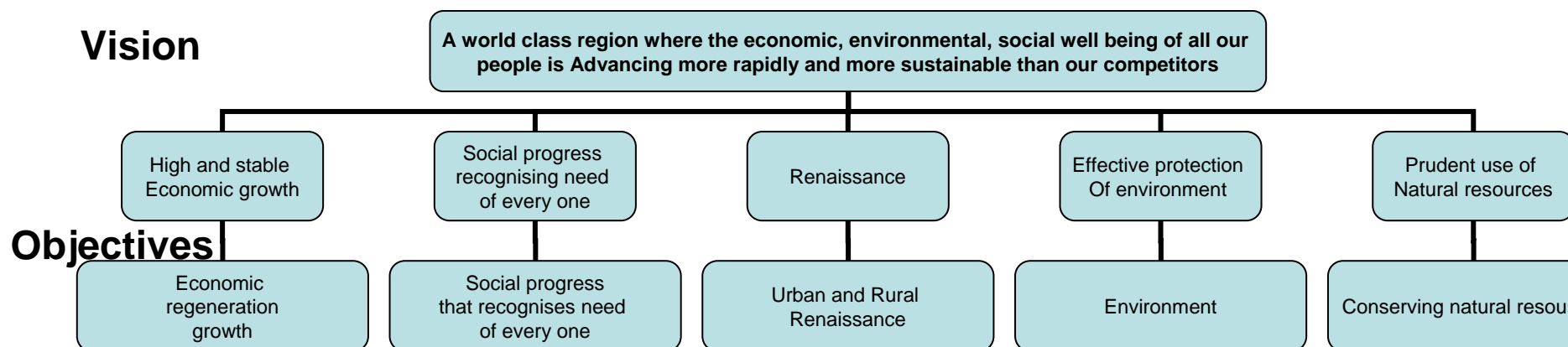
EUROPE



http://www.lib.utexas.edu/maps/europe/europe_ref_2003.jpg



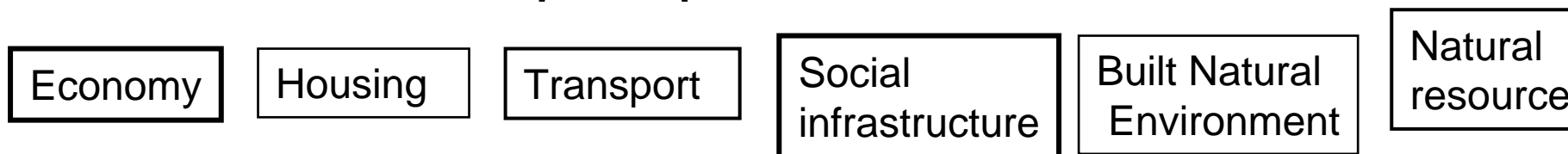
Regional Strategic Policies for Yorkshire and Humber to 2016



Strategic Themes Sustainable development policies

Strategic policies Regional Spatial Strategies

Specific policies



Source: Government Office Yorkshire and Humber 2004, RPG12, TSO

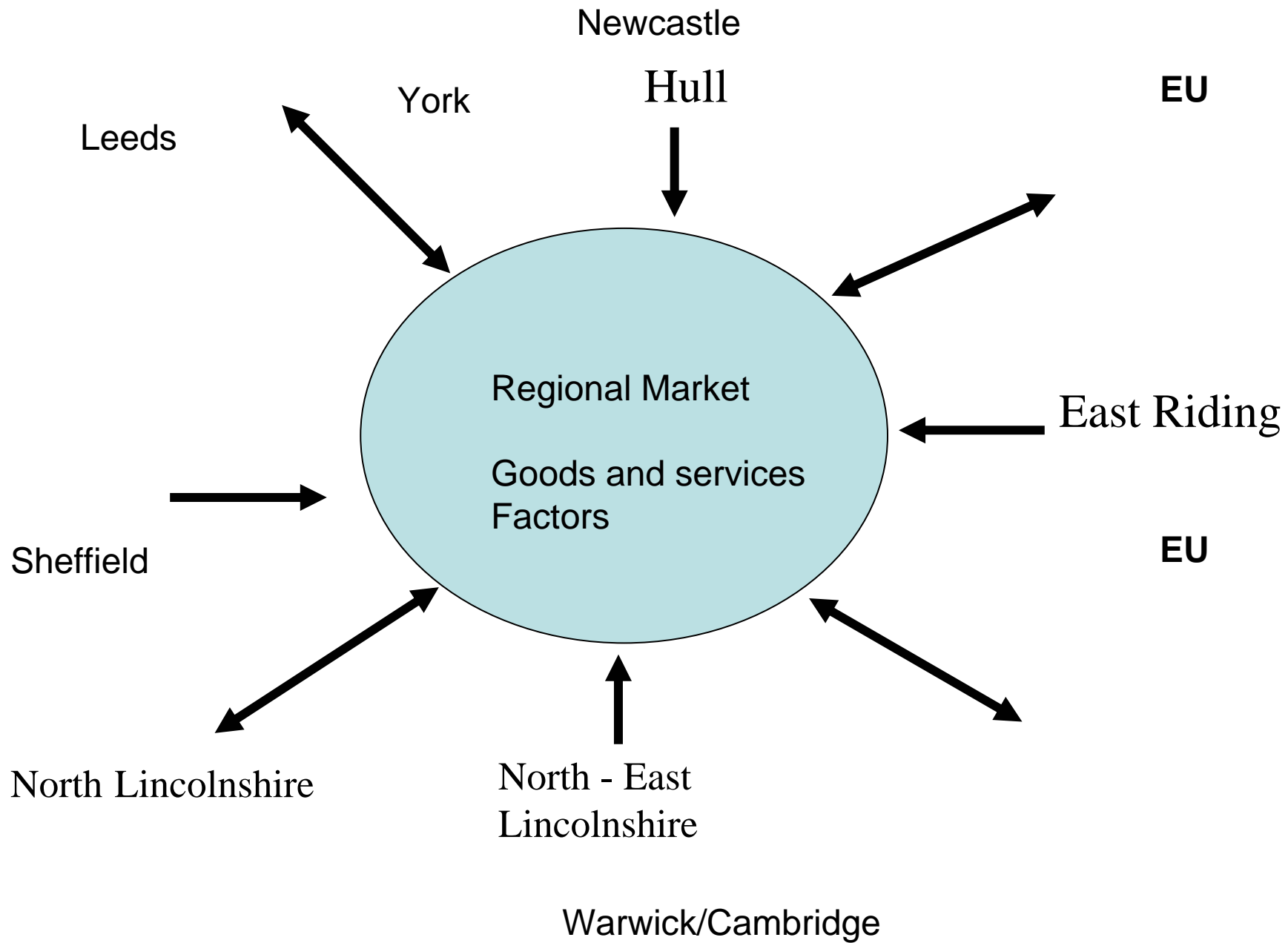








Table 1

Economy of Hull: Sectoral Composition of Employment and Output

| | Employers | Employment | Output 2002 (ml £) | Output 2012 |
|---|-----------|------------|--------------------|---------------|
| Agriculture and Fishing | 0.3% | 0.01% | 0.10% | 0.10% |
| Energy and Water | 0.1% | 0.60% | 1.30% | 1.30% |
| Manufacturing | 11.7% | 20.70% | 28.20% | 28.20% |
| Construction | 7.3% | 4.10% | 4.30% | 4.30% |
| Distribution, hotels and restaurants | 35.3% | 24.30% | 17.00% | 17.00% |
| Transport and communication | 5.4% | 5.40% | 9.70% | 9.70% |
| Banking, Finance and insurance | 19.6% | 12.60% | 12.40% | 12.40% |
| Public administration, education and health | 11.8% | 27.40% | 23.50% | 23.50% |
| Other services | 8.6% | 4.90% | 3.40% | 3.40% |
| Total | 7562 | 120856 | 3125881 | 3,125,881,000 |

Source: www.humberforum.com

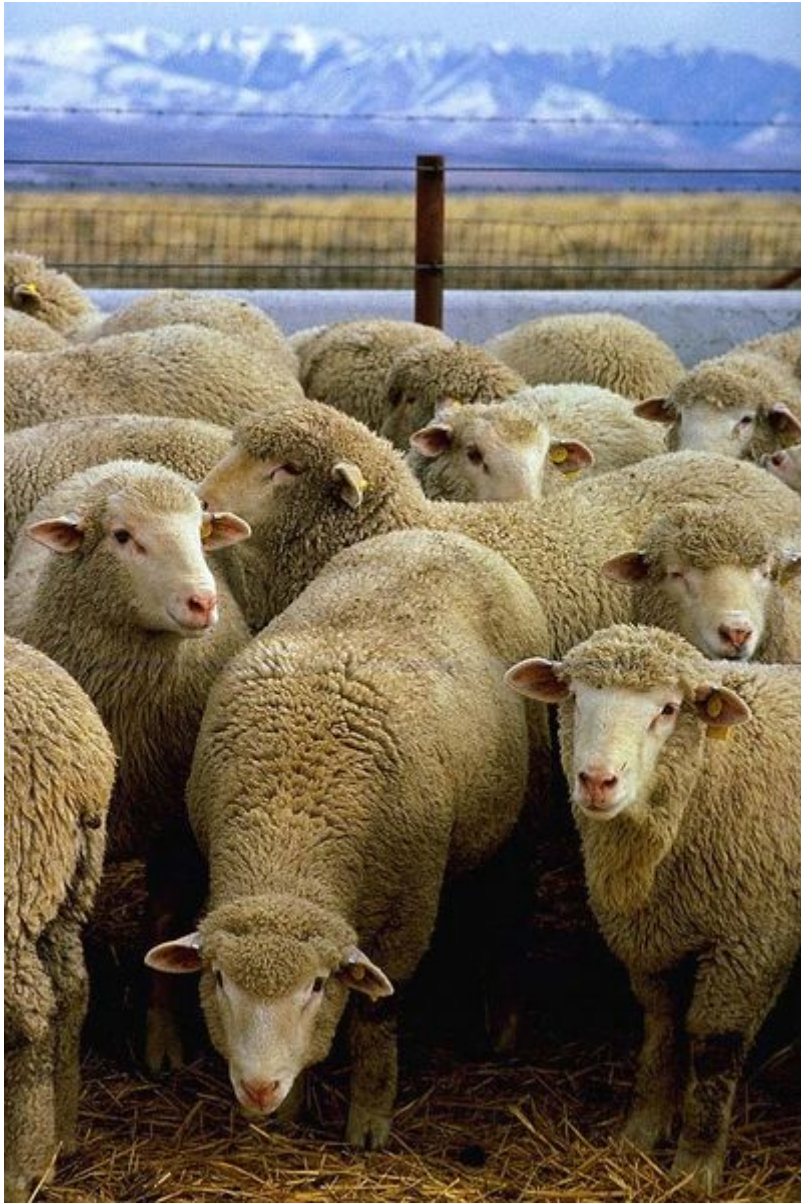
















Material Balance Equation

$$X_1 = X_{1,1} + X_{1,2} + \dots + X_{1,9} + F_1$$

$$X_2 = X_{2,1} + X_{2,2} + \dots + X_{2,9} + F_2$$

$$X_9 = X_{9,1} + X_{9,2} + \dots + X_{9,9} + F_9$$

Input-Output Model

$$X_1 = a_{1,1}X_1 + a_{1,2}X_2 + \dots + a_{1,9}X_9 + F_1$$

$$X_2 = a_{2,1}X_1 + a_{2,2}X_2 + \dots + a_{2,9}X_9 + F_2$$

$$X_9 = a_{9,1}X_1 + a_{9,2}X_2 + \dots + a_{9,9}X_9 + F_9$$

Input-Output Model

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \\ X_7 \\ X_8 \\ X_9 \end{bmatrix} = \begin{bmatrix} (1-a_{1,1}) & -a_{1,2} & -a_{1,3} & -a_{1,4} & -a_{1,5} & -a_{1,6} & -a_{1,7} & -a_{1,8} & -a_{1,9} \\ -a_{2,1} & (1-a_{2,1}) & & & & & & & \\ & & & & (1-a_{i,j}) & & & & \\ & & & & & & & & \\ & & & & & & & & \\ & & & & & & & & \\ & & & & & & & & \\ & & & & & & (1-a_{8,8}) & & \\ -a_{9,1} & -a_{9,1} & & -a_{9,j} & & & & & (1-a_{9,9}) \end{bmatrix}^{-1} \cdot \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \\ F_6 \\ F_7 \\ F_8 \\ F_9 \end{bmatrix}$$

$$X = (I - A)^{-1} F$$

$$|I - A| \neq 0$$

Derivation of Hull Regional Input-Output Tables

- Take the share of employment and output
- Production and household surveys is the best strategy
- Get the coefficients from the national 123 sector I-O table
- Get the structure of final demand and value added from the national table
- Use for the input-output model, general equilibrium analysis

Steps for Computing Input-Output Table for Hull

1. Take the total employment and output and sectoral composition of these employments and output from the existing data from the HF (Table 1).
2. Split the total output in labour and capital income using employment and income per capita information. Sectoral employment is obtained by multiplying the sectoral share by total employment. Then sectoral labour income is obtained by multiplying the sectoral employment by the gross value added per worker. Sectoral output is obtained by multiplying the sectoral share of output by total output. Capital income is the difference between total output and the labour income. All these numbers are presented in Table 2.
3. Analyses of inter-sectoral linkages require information on input-output coefficients which do not exist for the Hull and Humber. If the structure of production for each sector is not very different in Hull than in the national economy the Hull economy input-output coefficients can be approximated by the national input-output coefficients. Some adjustment is necessary for education and public services sector, and the mining and utility sector from the existing nine sector IO table for the national economy as given in Table 3. This needs to be refined when better data becomes available. It may not be too unrealistic if the regional coefficients do not vary significantly from the national coefficients.
4. Derive the gross output of Hull using the above Leontief coefficients assuming that final demand to be equal to total value added as in Table 4. Then decompose this final demand into consumption, investment, government consumption and export components again based on approximations from the national input-output table as in Table 5 until such information is obtained from the primary survey in Hull.
5. Derive tax or imports components as residuals in the supply side - gross output minus intermediate, labour and capitals costs altogether.

Table 2

Economy of Hull: Capital and Labour Income

| | Capital Income | Employees | Labour Income | Total Income |
|---|-------------------------|-------------------|-------------------------|-------------------------|
| Agriculture and Fishing | 2,967,039.9592 | 12.09 | 158,841.04 | 3,125,881.00 |
| Energy and Water | 31,105,990.5520 | 725.14 | 9,530,462.45 | 40,636,453.00 |
| Manufacturing | 552,697,487.5440 | 25,017.19 | 328,800,954.46 | 881,498,442.00 |
| Construction | 69,288,056.2720 | 4,955.10 | 65,124,826.73 | 134,412,883.00 |
| Distribution, hotels and restaurants | 145,416,040.8560 | 29,368.01 | 385,983,729.14 | 531,399,770.00 |
| Transport and communication | 217,436,294.9680 | 6,526.22 | 85,774,162.03 | 303,210,457.00 |
| Banking, Finance and insurance | 187,469,532.5920 | 15,227.86 | 200,139,711.41 | 387,609,244.00 |
| Public administration, education and health | 299,357,583.2080 | 33,114.54 | 435,224,451.79 | 734,582,035.00 |
| Other services | 28,447,844.0080 | 5,921.94 | 77,832,109.99 | 106,279,954.00 |
| Total | 1,534,185,869.96 | 120,868.09 | 1,588,569,249.04 | 3,122,755,119.00 |

Input-Output Coefficients for Hull

| | Agric | Enrwtr | Manu | Const | Distb | Trans | Busi | Edupub | OthSect |
|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Agric | 0.086583 | 0.000604 | 0.035177 | 4.74E-05 | 0.003639 | 0.000487 | 5.68E-05 | 0 | 0.000832 |
| Enrwtr | 0.000826 | 0.120376 | 0.016645 | 0.004751 | 0.000677 | 0.000173 | 3.03E-05 | 0.13229 | 0.000321 |
| Manu | 0.203363 | 0.068337 | 0.202288 | 0.152745 | 0.102854 | 0.083622 | 0.043803 | 0.040461 | 0.056192 |
| const | 0.007105 | 0.00526 | 0.000636 | 0.249816 | 0.003891 | 0.001532 | 0.022375 | 0 | 0.000821 |
| Distb | 0.041515 | 0.017505 | 0.037544 | 0.016244 | 0.026867 | 0.025066 | 0.008611 | 0.008509 | 0.004443 |
| Trans | 0.010121 | 0.044796 | 0.027601 | 0.010509 | 0.09595 | 0.158739 | 0.065376 | 0.004386 | 0.017857 |
| Busi | 0.080511 | 0.049237 | 0.073745 | 0.124203 | 0.14469 | 0.125707 | 0.249916 | 0.045159 | 0.075562 |
| Edupub | 0.011525 | 0.006898 | 0.019606 | 0.003223 | 0.007749 | 0.008697 | 0.004566 | 0.294183 | 0.003965 |
| OthSect | 0.015615 | 0.001811 | 0.012468 | 0.002867 | 0.006459 | 0.013893 | 0.015504 | 0.004291 | 0.043622 |

Matrix A

$$X = (I - A)^{-1} F$$

| | |
|---------|---------------|
| Agric | 62,648,983 |
| Utils | 242,181,122 |
| Manu | 1,452,733,597 |
| const | 218,010,053 |
| Distb | 647,427,906 |
| Trans | 587,275,170 |
| BusiFin | 1,025,074,800 |
| Edupub | 1,107,405,717 |
| OthSect | 166,690,690 |
| Total | 5,509,448,037 |

Structure of final demand for Hull IO Table

| | Consumption | Investment | Public spending | Exports | Total |
|---------|-------------|------------|-----------------|----------|-------|
| Agric | 0.772232 | 0.000115 | 0.004819 | 0.222834 | 1 |
| Enrwtr | 0.040784 | 0.00012 | 0.005654 | 0.953441 | 1 |
| Manu | 0.219586 | 0.097767 | 0.04372 | 0.638926 | 1 |
| Const | 0.921867 | 5.64E-05 | 0.074581 | 0.003495 | 1 |
| Distb | 0.062893 | 0.858263 | 0.078844 | 0 | 1 |
| Trans | 0.863897 | 0.020094 | 0.00955 | 0.106459 | 1 |
| BusiFin | 0.558103 | 0.022052 | 0.07465 | 0.345195 | 1 |
| Edupub | 0.727305 | 0.078453 | 0.078222 | 0.11602 | 1 |
| OthSect | 0.27582 | 6.32E-06 | 0.695715 | 0.028458 | 1 |

Input-Output Table of Hull (preliminary version September 2006)

| | Agric | Utils | Manu | const | Distb | Trans | BusiFin | Edupub | OthSect | Total IntD | Cons | Inv | Gov | Exp | FinDem | Gross Output |
|--------------|------------|-------------|---------------|-------------|--------------|-------------|---------------|---------------|-------------|---------------|---------------|-------------|-------------|-------------|---------------|---------------|
| Agric | 5,424,334 | 146,182 | 51,103,260 | 10,332 | 2,356,000 | 286,072 | 58,173 | 0 | 138,751 | 59,523,102 | 2,413,905 | 359 | 15,064 | 696,553 | 3,125,881 | 62,648,983 |
| Utils | 51,759 | 29,152,785 | 24,181,417 | 1,035,782 | 438,617 | 101,317 | 31,026 | 146,498,529 | 53,438 | 201,544,669 | 1,657,334 | 4,889 | 229,778 | 38,744,453 | 40,636,453 | 242,181,122 |
| Manu | 12,740,455 | 16,549,844 | 293,870,093 | 33,299,988 | 66,590,412 | 49,108,956 | 44,901,826 | 44,806,943 | 9,366,636 | 571,235,155 | 193,565,032 | 86,181,836 | 38,539,146 | 563,212,427 | 881,498,442 | 1,452,733,597 |
| const | 445,127 | 1,273,868 | 924,286 | 54,462,477 | 2,518,915 | 899,934 | 22,935,688 | 0 | 136,876 | 83,597,170 | 123,910,811 | 7,577 | 10,024,705 | 469,790 | 134,412,883 | 218,010,053 |
| Distb | 2,600,885 | 4,239,266 | 54,540,953 | 3,541,288 | 17,394,296 | 14,720,767 | 8,826,788 | 9,423,261 | 740,631 | 116,028,136 | 33,421,309 | 456,080,801 | 41,897,660 | 0 | 531,399,770 | 647,427,906 |
| Trans | 634,047 | 10,848,762 | 40,096,965 | 2,291,118 | 62,120,697 | 93,223,579 | 67,015,336 | 4,857,625 | 2,976,586 | 284,064,713 | 261,942,717 | 6,092,623 | 2,895,527 | 32,279,591 | 303,210,457 | 587,275,170 |
| BusiFin | 5,043,906 | 11,924,241 | 107,131,988 | 27,077,550 | 93,676,055 | 73,824,349 | 256,182,410 | 50,009,645 | 12,595,412 | 637,465,556 | 216,326,008 | 8,547,703 | 28,934,907 | 133,800,626 | 387,609,244 | 1,025,074,800 |
| Edupub | 722,037 | 1,670,647 | 28,482,588 | 702,575 | 5,016,943 | 5,107,570 | 4,680,990 | 325,779,390 | 660,943 | 372,823,682 | 534,264,949 | 57,630,395 | 57,460,555 | 85,226,136 | 734,582,035 | 1,107,405,717 |
| OthSect | 978,243 | 438,545 | 18,112,753 | 625,085 | 4,181,482 | 8,159,000 | 15,892,873 | 4,751,447 | 7,271,307 | 60,410,736 | 29,314,185 | 672 | 73,940,538 | 3,024,559 | 106,279,954 | 166,690,690 |
| Total IntDem | 28,640,792 | 76,244,139 | 618,444,303 | 123,046,194 | 254,293,417 | 245,431,543 | 420,525,111 | 586,126,840 | 33,940,580 | | | | | | | 2,386,692,918 |
| Labour | 158,841 | 9,530,462 | 328,800,954 | 65,124,827 | 385,983,729 | 85,774,162 | 200,139,711 | 435,224,452 | 77,832,110 | | | | | | | 1,588,569,249 |
| Capital | 2,967,040 | 31,105,991 | 552,697,488 | 69,288,056 | 145,416,041 | 217,436,295 | 187,469,533 | 299,357,583 | 28,447,844 | | | | | | | 1,534,185,870 |
| Taxes | 31,265,941 | 118,511,672 | -46,141,443 | -28,339,275 | -134,049,400 | 30,906,536 | 157,066,037 | -109,267,613 | 18,187,479 | | | | | | | 38,139,935 |
| Imports | -383,631 | 6,788,858 | -1,067,705 | -11,109,749 | -4,215,881 | 7,726,634 | 59,874,408 | -104,035,545 | 8,282,676 | | | | | | | -38,139,935 |
| Gross output | 62,648,983 | 242,181,122 | 1,452,733,597 | 218,010,053 | 647,427,906 | 587,275,170 | 1,025,074,800 | 1,107,405,717 | 166,690,690 | 2,386,692,918 | 1,396,816,251 | 614,546,854 | 253,937,879 | 857,454,135 | 3,122,755,119 | |

Input-Output Table of East Riding (preliminary version September 2006)

| | Agric | Utils | Manu | const | Distb | Trans | BusiFin | Edupub | OthSect | Cons | Inv | Gov | Exp | FinDem | Gross Output |
|--------------|-------------|------------|-------------|-------------|--------------|-------------|-------------|-------------|------------|---------------|-------------|-------------|-------------|---------------|---------------|
| Agric | 25,267,934 | 123,704 | 42,455,598 | 14,280 | 2,277,232 | 245,991 | 50,538 | 0 | 110,998 | 170,886,181 | 25,392 | 1,066,452 | 49,310,693 | 221,288,717 | 291,834,991 |
| Utils | 241,106 | 24,670,047 | 20,089,453 | 1,431,577 | 423,953 | 87,122 | 26,954 | 104,707,348 | 42,749 | 2,170,601 | 6,403 | 300,939 | 50,743,395 | 53,221,337 | 204,941,645 |
| Manu | 59,348,301 | 14,005,023 | 244,141,580 | 46,024,656 | 64,364,117 | 42,228,370 | 39,008,879 | 32,025,005 | 7,493,089 | 144,545,774 | 64,356,770 | 28,779,323 | 420,582,039 | 658,263,905 | 1,206,902,925 |
| const | 2,073,514 | 1,077,989 | 767,878 | 75,273,803 | 2,434,701 | 773,845 | 19,925,592 | 0 | 109,498 | 183,340,677 | 11,211 | 14,832,735 | 695,109 | 198,879,733 | 301,316,553 |
| Distb | 12,115,589 | 3,587,407 | 45,311,567 | 4,894,493 | 16,812,759 | 12,658,261 | 7,668,354 | 6,735,117 | 592,487 | 32,415,454 | 442,354,481 | 40,636,698 | 0 | 515,406,632 | 625,782,665 |
| Trans | 2,953,551 | 9,180,580 | 33,311,782 | 3,166,605 | 60,043,836 | 80,162,155 | 58,220,196 | 3,471,905 | 2,381,199 | 217,789,452 | 5,065,645 | 2,407,455 | 26,838,518 | 252,101,070 | 504,992,879 |
| BusiFin | 23,495,803 | 10,090,685 | 89,003,180 | 37,424,486 | 90,544,215 | 63,480,924 | 222,560,848 | 35,743,548 | 10,076,034 | 171,964,767 | 6,794,854 | 23,001,323 | 106,362,585 | 308,123,530 | 890,543,254 |
| Edupub | 3,363,432 | 1,413,756 | 23,662,782 | 971,045 | 4,849,213 | 4,391,955 | 4,066,654 | 232,845,313 | 528,739 | 374,857,653 | 40,435,359 | 40,316,193 | 59,797,427 | 515,406,632 | 791,499,521 |
| OthSect | 4,556,908 | 371,111 | 15,047,724 | 863,944 | 4,041,684 | 7,015,854 | 13,807,081 | 3,396,017 | 5,816,875 | 21,632,997 | 496 | 54,565,917 | 2,232,035 | 78,431,444 | 133,348,642 |
| Labour | 9,647,823 | 9,647,823 | 184,380,610 | 48,239,113 | 249,771,407 | 55,742,975 | 100,766,147 | 377,337,062 | 35,375,350 | | | | | | 1,070,908,309 |
| Capital | 211,640,894 | 43,573,514 | 473,883,295 | 150,640,620 | 265,635,225 | 196,358,095 | 207,357,383 | 138,069,570 | 43,056,094 | | | | | | 1,730,214,691 |
| imports | -63,650,855 | 82,475,457 | 34,059,348 | -48,582,454 | -131,286,684 | 33,477,865 | 157,170,426 | -73,167,422 | 19,077,523 | | | | | | 9,573,205 |
| taxes | 780,992 | 4,724,549 | 788,127 | -19,045,613 | -4,128,993 | 8,369,466 | 59,914,201 | -69,663,942 | 8,688,007 | | | | | | -9,573,205 |
| Gross output | 291834991.5 | 204941645 | 1206902925 | 301316553.2 | 625782665.5 | 504992878.8 | 890543254.2 | 791499521.1 | 133348642 | 1,319,603,554 | 559,050,611 | 205,907,034 | 716,561,801 | 2,801,123,000 | |

Input-Output Table of North East Lincolnshire (preliminary version September 2006)

| | Agric | Utils | Manu | const | Distb | Trans | BusiFin | Edupub | OthSect | Total IntD | Cons | Inv | Gov | Exp | FinDem |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------|-------------|-------------|-------------|-------------|---------------|
| Agric | 3,662,300 | 80,906 | 28,077,835 | 7,676 | 1,399,997 | 178,139 | 31,282 | 0 | 65,900 | 33,504,035 | 6,791,111 | 1,009 | 42,381 | 1,959,634 | 8,794,135 |
| Utils | 34,946 | 16,134,984 | 13,286,077 | 769,476 | 260,638 | 63,091 | 16,684 | 78,823,409 | 25,381 | 109,414,685 | 1,004,258 | 2,962 | 139,233 | 23,477,124 | 24,623,578 |
| Manu | 8,601,863 | 9,159,724 | 161,462,031 | 24,738,378 | 39,569,776 | 30,580,468 | 24,145,357 | 24,108,337 | 4,448,724 | 326,814,659 | 103,505,463 | 46,084,206 | 20,608,124 | 301,167,843 | 471,365,636 |
| const | 300,532 | 705,039 | 507,833 | 40,459,874 | 1,496,805 | 560,394 | 12,333,360 | 0 | 65,010 | 56,428,849 | 97,284,282 | 5,949 | 7,870,550 | 368,839 | 105,529,620 |
| Distb | 1,756,017 | 2,346,276 | 29,966,619 | 2,630,803 | 10,336,149 | 9,166,718 | 4,746,488 | 5,070,178 | 351,766 | 66,371,013 | 20,021,831 | 273,226,065 | 25,099,791 | 0 | 318,347,687 |
| Trans | 428,084 | 6,004,387 | 22,030,610 | 1,702,059 | 36,913,753 | 58,050,932 | 36,036,602 | 2,613,641 | 1,413,742 | 165,193,809 | 173,216,847 | 4,028,915 | 1,914,747 | 21,345,770 | 200,506,278 |
| BusiFin | 3,405,450 | 6,599,625 | 58,861,888 | 20,115,763 | 55,664,777 | 45,970,905 | 137,758,670 | 26,907,647 | 5,982,245 | 361,266,969 | 106,013,577 | 4,188,921 | 14,179,955 | 65,570,863 | 189,953,316 |
| Edupub | 487,491 | 924,641 | 15,649,284 | 521,939 | 2,981,199 | 3,180,517 | 2,517,140 | 175,285,322 | 313,918 | 201,861,451 | 286,541,495 | 30,908,821 | 30,817,731 | 45,709,202 | 393,977,248 |
| OthSect | 660,472 | 242,718 | 9,951,751 | 464,372 | 2,484,747 | 5,080,663 | 8,546,180 | 2,556,512 | 3,453,538 | 33,440,953 | 12,613,132 | 289 | 31,814,692 | 1,301,389 | 45,729,502 |
| Total IntDem | 19,337,155 | 42,198,301 | 339,793,928 | 91,410,341 | 151,107,840 | 152,831,826 | 226,131,763 | 315,365,045 | 16,120,224 | 1,354,296,423 | 806,991,996 | 358,447,137 | 132,487,203 | 460,900,664 | 1,758,827,000 |
| Labour | 4,416,096 | 4,416,096 | 153,680,145 | 43,277,742 | 242,885,287 | 68,007,880 | 107,752,745 | 230,520,217 | 27,379,796 | 882,336,005 | | | | | |
| Capital | 4,378,039 | 20,207,482 | 317,685,491 | 62,251,878 | 75,462,400 | 132,498,398 | 82,200,571 | 163,457,031 | 18,349,706 | 876,490,995 | | | | | |
| imp | 14,342,866 | 63,574,560 | -12,685,724 | -25,129,902 | -82,153,096 | 9,889,587 | 97,838,609 | -58,143,850 | 11,900,966 | 19,434,015 | | | | | |
| tax | -175,986 | 3,641,824 | -293,545 | -9,851,590 | -2,583,732 | 2,472,397 | 37,296,597 | -55,359,744 | 5,419,764 | -19,434,015 | | | | | |
| Gross output | 42298170.28 | 134038262.9 | 798180294.6 | 161958468.5 | 384718700.2 | 365700087.2 | 551220284.7 | 595838699.5 | 79170455.36 | 3,132,557,438 | 806,991,996 | 358,447,137 | 132,487,203 | 460,900,664 | 1,758,827,000 |

Input-Output Table of North Lincolnshire (preliminary version September 2006)

| | Agric | Utils | Manu | const | Distb | Trans | BusiFin | Edupub | OthSect | Total IntD | Cons | Inv | Gov | Exp | FinDem |
|--------------|------------|-------------|---------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------|-------------|-------------|-------------|-------------|---------------|
| Agric | 7,271,493 | 87,967 | 40,772,323 | 11,184 | 1,700,571 | 226,136 | 43,015 | 0 | 97,661 | 50,210,350 | 26,080,291 | 3,875 | 162,760 | 7,525,695 | 33,772,620 |
| Utils | 69,384 | 17,543,091 | 19,292,948 | 1,121,233 | 316,596 | 80,090 | 22,941 | 68,976,307 | 37,612 | 107,460,203 | 1,561,049 | 4,605 | 216,429 | 36,493,553 | 38,275,636 |
| Manu | 17,078,989 | 9,959,097 | 234,461,881 | 36,047,206 | 48,065,243 | 38,820,014 | 33,201,980 | 21,096,576 | 6,592,745 | 445,323,732 | 156,724,940 | 69,779,355 | 31,204,217 | 456,019,524 | 713,728,036 |
| const | 596,706 | 766,568 | 737,434 | 58,955,581 | 1,818,163 | 711,386 | 16,959,450 | 0 | 96,341 | 80,641,629 | 143,215,785 | 8,758 | 11,586,527 | 542,982 | 155,354,052 |
| Distb | 3,486,570 | 2,551,037 | 43,515,059 | 3,833,441 | 12,555,277 | 11,636,582 | 6,526,836 | 4,436,780 | 521,296 | 89,062,878 | 23,789,476 | 324,640,878 | 29,822,990 | 0 | 378,253,344 |
| Trans | 849,960 | 6,528,393 | 31,991,040 | 2,480,133 | 44,838,983 | 73,692,070 | 49,553,483 | 2,287,129 | 2,095,082 | 214,316,272 | 215,902,975 | 5,021,767 | 2,386,602 | 26,606,045 | 249,917,388 |
| BusiFin | 6,761,517 | 7,175,577 | 85,474,392 | 29,311,423 | 67,615,776 | 58,357,222 | 189,430,231 | 23,546,179 | 8,865,331 | 476,537,649 | 157,071,763 | 6,206,386 | 21,009,294 | 97,151,056 | 281,438,500 |
| Edupub | 967,913 | 1,005,335 | 22,724,603 | 760,537 | 3,621,251 | 4,037,470 | 3,461,288 | 153,387,609 | 465,207 | 190,431,212 | 240,717,248 | 25,965,825 | 25,889,302 | 38,399,302 | 330,971,676 |
| OthSect | 1,311,367 | 263,900 | 14,451,114 | 676,654 | 3,018,211 | 6,449,587 | 11,751,746 | 2,237,137 | 5,117,939 | 45,277,655 | 19,872,383 | 455 | 50,125,039 | 2,050,379 | 72,048,256 |
| Total IntDem | 38,393,900 | 45,880,965 | 493,420,793 | 133,197,392 | 183,550,072 | 194,010,558 | 310,950,971 | 275,967,717 | 23,889,214 | 1,699,261,580 | 984,935,909 | 431,631,905 | 172,403,159 | 664,788,535 | 2,253,759,508 |
| Labour | 2,708,849 | 7,223,598 | 196,843,045 | 76,750,728 | 211,290,241 | 82,168,427 | 97,518,573 | 197,745,995 | 31,603,241 | 903,852,697 | | | | | |
| Capital | 31,063,771 | 31,052,038 | 516,884,991 | 78,603,324 | 166,963,103 | 167,748,961 | 183,919,927 | 133,225,681 | 40,445,015 | 1,349,906,811 | | | | | |
| Taxes | 11,963,238 | 58,242,838 | -47,009,274 | -37,754,856 | -91,606,162 | 16,244,571 | 119,885,636 | -43,817,306 | 14,695,865 | 844,552 | | | | | |
| Imports | -146,788 | 3,336,400 | -1,087,786 | -14,800,907 | -2,881,032 | 4,061,143 | 45,701,041 | -41,719,199 | 6,692,576 | -844,552 | | | | | |
| Gross output | 83,982,970 | 145,735,839 | 1,159,051,768 | 235,995,681 | 467,316,222 | 464,233,660 | 757,976,149 | 521,402,888 | 117,325,911 | 3,953,021,088 | 984,935,909 | 431,631,905 | 172,403,159 | 664,788,535 | 2,253,759,508 |

Short-Run Impact Analysis with Input-Output Model

$$\Delta X = (I - A)^{-1} \Delta F$$

$$\Delta X = (I - A)^{-1} \Delta C_{man} \quad (0.1)$$

$$\Delta L = \sum_i l_i (I - A)^{-1} \Delta C_{man} \quad (0.1)$$

$$\Delta K = \sum_i k_i (I - A)^{-1} \Delta C_{man} \quad (0.1)$$

$$M_{s,i} = IOM_{s,i} X_i$$

Production Functions Across Regions of the Humber Economy

$$Y_{i,r} = \min \left(\frac{INT_{j,i,r}}{a_{i,j,r}}, \left(K_{i,r}^{\beta_r} L_{i,r}^{1-\beta_r} \right) \right) \quad (1)$$

Here $Y_{i,r}$ is output of the sector i good in region r ,

$K_{i,r}$ is capital services originating in region r but used to produce the good i in region r ,

$L_{i,r}$ are labour services originating in region r but used to produce the sector i good in region r ,

$INT_{j,i,r}$ is an intermediate input originating in sector j of region r but used to produce the sector i good in region r ,

$a_{j,i,r}$ is a coefficient that gives the amount of the sector j intermediate input of region r used to produce the sector i good in region r , and β_r is the share of capital income in sectoral output in region r .

Land and natural resources are additional inputs in case of agriculture sector.

Production, Trade and Transport Across Regions of Humber Economy

$$Y_{i,r} = \left(\delta_{i,r} YD_{i,r}^{\eta_{i,r}} + (1 - \delta_{i,r}) X_{i,r}^{\eta_{i,r}} \right)^{\frac{1}{\eta_{i,r}}} \quad (2)$$

where $YD_{i,r}$ is domestic sales of output of good i in region r , $X_{i,r}$ is exports of good i from a region r , $\delta_{i,r}$ is the share of domestic sales of gross output, $Y_{i,r}$, and $\eta_{i,r}$ is the

Absorption of region, r is given by a CES aggregation of imports and domestic supplies

$$A_{i,r} = \left(\mu_{i,r} YD_{i,r}^{\sigma_{i,r}} + (1 - \mu_{i,r}) M_{i,r}^{\sigma_{i,r}} \right)^{\frac{1}{\sigma_{i,r}}} \quad (3)$$

Transportation services are proportional to trade:

$$T_{i,r,s} = \tau_{i,r,s} M_{i,r,s} \quad (4)$$

Here $T_{i,r,s}$ transportation services, $\tau_{i,r,s}$ is transport cost per unit of traded goods

$M_{i,r,s}$ amount of good i traded from region r to s .

Household consumption is a Cobb-Douglas aggregation of sector i commodities over all r regions.

$$U_r = \prod_{i,r} C_{i,r}^\gamma \quad (5)$$

Households receive factor income from all regions and transfers from their own government. The income of the representative household in each region is

$$I_r = \sum_i w_r L_{i,r} + \sum_r r_r K_{i,r} + RV_r \quad (7)$$

where I_r is income, w_r is wage rate and r_r is the interest rate and RV_r is the transfer received by a representative household in region r .

Government consumption demand reflects a Cobb-Douglas aggregate of all sector i commodities over all r regions.

$$G_r = \prod_{i,r} GD_{i,r}^\gamma \quad (8)$$

$GD_{i,r}^g$ is the government consumption of good i in region r . The government in each region collects taxes from factors income, intermediate inputs, imports and domestic sales.

Market Clearing Conditions in Humber Market

$$G_r = \tau_k r_r \bar{K}_r + \tau_w w_r \bar{L}_r + \tau_{i,r} P_{i,r} Y_{i,r} + \tau_{N,r} P_{i,r} INT_{j,i,r} \quad (9)$$

Here G_r is total government revenue, $\tau_{k,r}$ is tax rate on capital income, $\tau_{w,rr}$ is tax rate on labour income, $\tau_{w,r}$ is tax rate in wage income, $\tau_{i,r}$ is tax rate on intermediate income, $\tau_{N,r}$ is tax rate on intermediate input.

the market clearing condition for the goods market is given by

$$Y_{i,r} = \sum_r C_{i,r} + \sum_{rr,j} a_{i,j,r} INT_{i,j,r} \quad (10)$$

The global capital market clearing condition implies

$$\sum_r \bar{K}_r = \sum_{i,r} K_{r,ri} \quad (11)$$

and labour market clears at the regional level:

$$LS_r = \sum_i LS_{i,r} \quad (12)$$

When there are $r.n$ different markets in the economy, relative prices that clear $rn-1$ markets also clear the rn th market as well.

Sectoral and Regional Comparison of Labour, Capital, Domestic Output and Supply: Results from the Regional General Equilibrium Model of Humber Regions

| | LABOUR | CAPITAL | DOMOUT | SUPPLY | DOMOUTR | SUPPLYR | LABOURR | CAPITALR |
|--------------|-----------|-----------|------------|------------|---------|---------|---------|----------|
| AGRIC .HULL | 158841 | 2967040 | 62336060 | 61952430 | 1.000 | 1.000 | 1.000 | 1.000 |
| AGRIC .ER | 9647823 | 211640900 | 306175200 | 242524300 | 4.912 | 3.915 | 60.739 | 71.331 |
| AGRIC .NL | 2708849 | 31063770 | 76604060 | 76457270 | 1.229 | 1.234 | 17.054 | 10.470 |
| AGRIC .NEL | 4416096 | 4378039 | 25995670 | 40338540 | 0.417 | 0.651 | 27.802 | 1.476 |
| UTILS .HULL | 9530462 | 31105990 | 196647800 | 203436700 | 1.000 | 1.000 | 1.000 | 1.000 |
| UTILS .ER | 9647823 | 43573510 | 71722790 | 154198200 | 0.365 | 0.758 | 1.012 | 1.401 |
| UTILS .NL | 7223598 | 31052040 | 105905900 | 109242300 | 0.539 | 0.537 | 0.758 | 0.998 |
| UTILS .NEL | 4416096 | 20207480 | 46986580 | 110561100 | 0.239 | 0.543 | 0.463 | 0.650 |
| MANU .HULL | 328801000 | 552697500 | 890588900 | 889521200 | 1.000 | 1.000 | 1.000 | 1.000 |
| MANU .ER | 184380600 | 473883300 | 752261500 | 786320900 | 0.845 | 0.884 | 0.561 | 0.857 |
| MANU .NL | 196843000 | 516885000 | 704120000 | 703032200 | 0.791 | 0.790 | 0.599 | 0.935 |
| MANU .NEL | 153680100 | 317685500 | 509698200 | 497012500 | 0.572 | 0.559 | 0.467 | 0.575 |
| CONST .HULL | 65124830 | 69288060 | 228650000 | 217540300 | 1.000 | 1.000 | 1.000 | 1.000 |
| CONST .ER | 48239110 | 150640600 | 349203900 | 300621400 | 1.527 | 1.382 | 0.741 | 2.174 |
| CONST .NL | 76750730 | 78603320 | 250253600 | 235452700 | 1.094 | 1.082 | 1.179 | 1.134 |
| CONST .NEL | 43277740 | 62251880 | 186719500 | 161589600 | 0.817 | 0.743 | 0.665 | 0.898 |
| DISTB .HULL | 385983700 | 145416000 | 651643800 | 647427900 | 1.000 | 1.000 | 1.000 | 1.000 |
| DISTB .ER | 249771400 | 265635200 | 757069300 | 625782700 | 1.162 | 0.967 | 0.647 | 1.827 |
| DISTB .NL | 211290200 | 166963100 | 470197300 | 467316200 | 0.722 | 0.722 | 0.547 | 1.148 |
| DISTB .NEL | 242885300 | 75462400 | 466871800 | 384718700 | 0.716 | 0.594 | 0.629 | 0.519 |
| TRANS .HULL | 85774160 | 217436300 | 547268900 | 554995600 | 1.000 | 1.000 | 1.000 | 1.000 |
| TRANS .ER | 55742970 | 196358100 | 444676500 | 478154400 | 0.813 | 0.862 | 0.650 | 0.903 |
| TRANS .NL | 82168430 | 167749000 | 433566500 | 437627600 | 0.792 | 0.789 | 0.958 | 0.771 |
| TRANS .NEL | 68007880 | 132498400 | 334464700 | 344354300 | 0.611 | 0.620 | 0.793 | 0.609 |
| BUSIFIN.HULL | 200139700 | 187469500 | 831399800 | 891274200 | 1.000 | 1.000 | 1.000 | 1.000 |
| BUSIFIN.ER | 100766100 | 207357400 | 627010200 | 784180700 | 0.754 | 0.880 | 0.503 | 1.106 |
| BUSIFIN.NL | 97518570 | 183919900 | 615124100 | 660825100 | 0.740 | 0.741 | 0.487 | 0.981 |
| BUSIFIN.NEL | 107752700 | 82200570 | 387810800 | 485649400 | 0.466 | 0.545 | 0.538 | 0.438 |
| EDUPUB .HULL | 435224500 | 299357600 | 1126215000 | 1022180000 | 1.000 | 1.000 | 1.000 | 1.000 |
| EDUPUB .ER | 377337100 | 138069600 | 804869500 | 731702100 | 0.715 | 0.716 | 0.867 | 0.461 |
| EDUPUB .NL | 197746000 | 133225700 | 524722800 | 483003600 | 0.466 | 0.473 | 0.454 | 0.445 |
| EDUPUB .NEL | 230520200 | 163457000 | 608273300 | 550129500 | 0.540 | 0.538 | 0.530 | 0.546 |
| OTHSECT.HULL | 77832110 | 28447840 | 155383500 | 163666100 | 1.000 | 1.000 | 1.000 | 1.000 |
| OTHSECT.ER | 35375350 | 43056090 | 112039100 | 131116600 | 0.721 | 0.801 | 0.455 | 1.514 |
| OTHSECT.NL | 31603240 | 40445010 | 108583000 | 115275500 | 0.699 | 0.704 | 0.406 | 1.422 |
| OTHSECT.NEL | 27270800 | 48240710 | 65069100 | 77860070 | 0.425 | 0.476 | 0.352 | 0.645 |

Dynamic Model of Humber Region: Consumer's Problem and Demand

$$U(C_t^h) = \frac{(C_t^h)^{\frac{1}{1-\sigma}} - 1}{1-\sigma}$$

$$C_t^h = \left(\prod_{i=1}^{11} C_{i,t}^{\alpha_i^h} \right)$$

$$U_t^h = \left(\frac{\prod_{i=1}^{11} C_{i,t}^{\alpha_i^h}}{1-\sigma} \right)^{1-\sigma}$$

$$\sum_{t=0}^{\infty} P_t C_t^h = \sum_t w_t^h L_t^h + M_o^h$$

$$\frac{C_{t+1}}{C_t} = \frac{\bar{C}_{t+1}}{\bar{C}_t} \left(\frac{P_t}{P_{t+1}} \right)^{\sigma} \left(\frac{\bar{P}_{t+1}}{\bar{P}_t} \right)^{\sigma} (1+g)(1+r)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right)^{\frac{1}{\sigma}}$$

Producer and Investor's Problem

$$\Pi_{j,t}^y = [(\theta_j^x PX_{j,t}^{1+\eta} + (1 - \theta_j^x) PD_{j,t}^{1+\eta})]^{\frac{1}{1+\eta}} - \theta^v PV_j^v - (1 - \theta^v) \sum_j a_{i,j} P_{i,t} \leq 0$$

$$\Pi_{j,t}^I = P_{t+1}^k - \sum_i P_{i,t}^A a_{i,j}^I \leq 0$$

$$\Pi_{j,t}^k = (1 - \delta) P_{j,t+1}^k + r_{j,t}^k - P_{j,t}^k \leq 0$$

$$K_{j,t+1} = I_{j,t} + (1 - \delta) K_{j,t}$$

$$I_{j,t} = (g + \delta_j) K_{j,t}$$

Armington Conditions for Trade

$$\mathfrak{R}_{i,,w,,t} = PE_{i,t}E_{i,t} + PXE_{i,t}XE - P_{i,t}Y_{i,t}$$

$$+ \Phi_{e,w,t} \left[Y_{i,t} - \Psi(\gamma_i E_{i,t}^{\chi_i} + (1 - \gamma_i) XE_{i,t}^{\chi_i})^{\frac{1}{\chi_i}} \right]$$

$$Y_{i,t} = \Psi(\gamma_i E_{i,t}^{\chi_i} + (1 - \gamma_i) XE_{i,t}^{\chi_i})^{\frac{1}{\chi_i}}$$

$$PD_{i,t}Y_{i,t} = PE_{i,t}E_{i,t} + PXE_{i,t}XE_{i,t}$$

Definition of a Competitive Equilibrium in the Economy

prices of composite commodities, $P_{i,t}$;

Prices of domestic goods sold in domestic markets, $P D_{i,t}$;

prices of exported commodities, $P X_{i,t}$;

prices of capital goods , $P_{j,t}^k$;

prices of terminal capital , $P T K_{j,t}$;

wage rates for each categories of labor, $w_{h,t}$;

prices of government services, $P G_t$;

prices of provisions for tourism, $P T_t$;

prices of transfer, $P R_t$;

prices of consumption, $P U_t$;

price of aggregate welfare, $P W_t$;

price of foreign exchange, $P F X_t$,

present value of foreign exchange, $P V P F X_t$;

rental rate of capital for each sector, $r_1^k : \mathbf{R}_+ \rightarrow \mathbf{R}$, and

sequence of gross output, $Y_{i,t}$; total supply of commodities, $A_{i,t}$; sectoral capital

stock, $K_{i,t}$; sectoral investment, $I_{i,t}$;

exports, $X_{i,t}$; government services, $G O V_t$;

level of household utility from consumption, U_t ; and total welfare, W such that given these prices and commodities

- i) households solve intertemporal utility maximization problems
- ii) investors solve intertemporal profit maximization problem,
- iii) markets for goods and services, labor , capital clear
- iv) government constraint is satisfied
- v) and balance of payments condition is fulfilled

Calibration of the Dynamic Model

$$P_1^I = 1 = P_2^k = (1-r)P_1^k \Rightarrow P_1^k = \frac{1}{1-r}$$

$$\frac{P_{t+1}^k}{P_t^k} = (1-r) \quad P_1^k = r_1^k + (1-\delta)(1-r)P_1^k$$

$$\frac{1}{1-r} = r_1^k + (1-\delta) \quad V_1 = r_1^k K_1$$

$$K_1 = \frac{V_1}{\frac{r}{1-r} + \delta} \quad \frac{I_1}{V_1} = \frac{\delta + g}{\frac{r}{1-r} + \delta} \quad \frac{I_1}{V_1} = 1$$

$$g = \frac{r}{1-r} \quad r = \frac{g}{1+g} \quad \frac{I_1}{V_1} \neq 1$$

$$\delta_j = g \frac{V_j}{I_j - V_j} - \frac{r}{1-r} \frac{I_j}{I_j - V_j}$$

Figure 1
Growth Rates of Investment by Sectors in Humber Region GE Model Over 21st Century

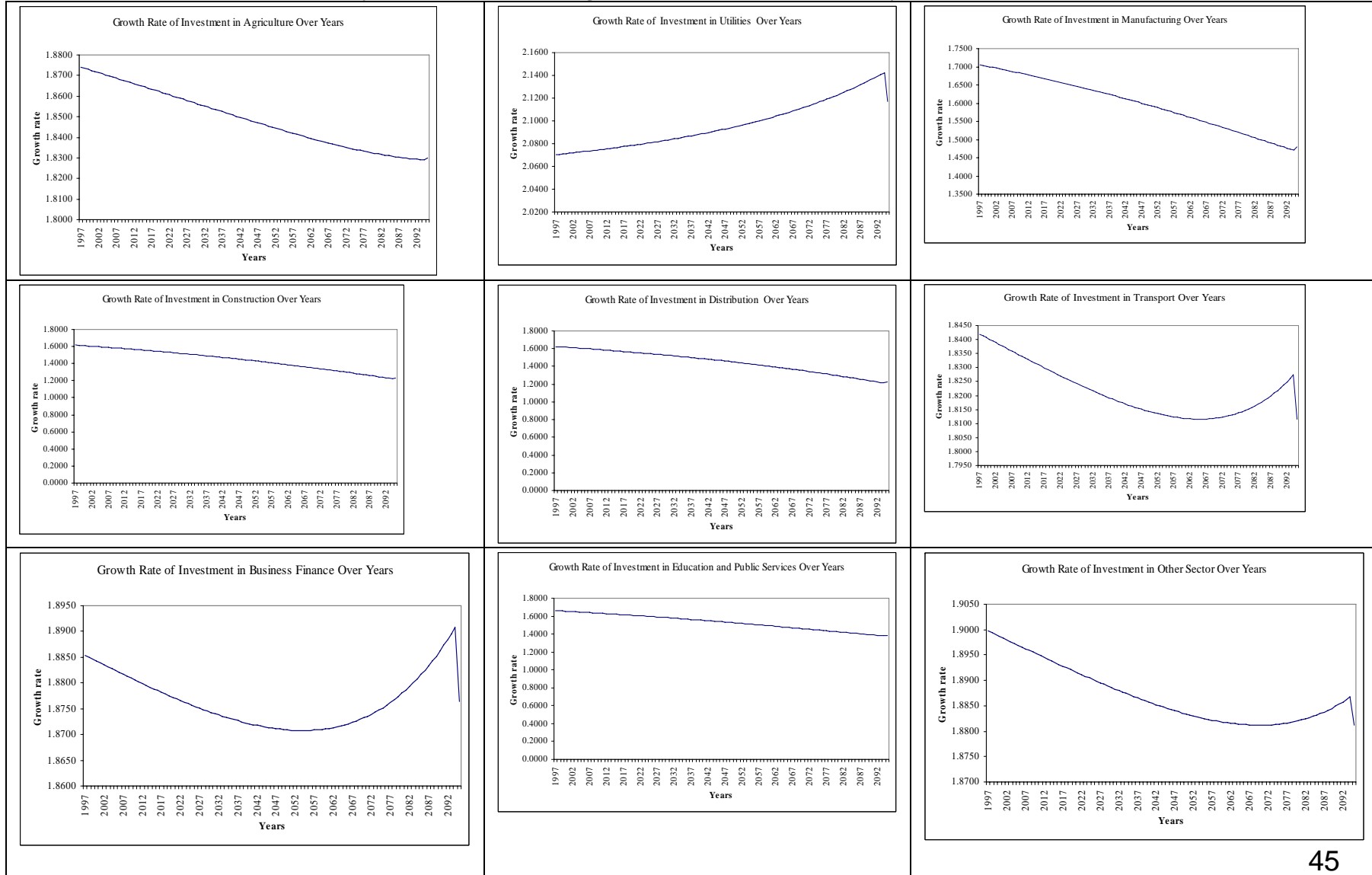


Figure 2
Growth Rates of Capital Stock by Sectors in Humber Region GE Model Over 21st Century

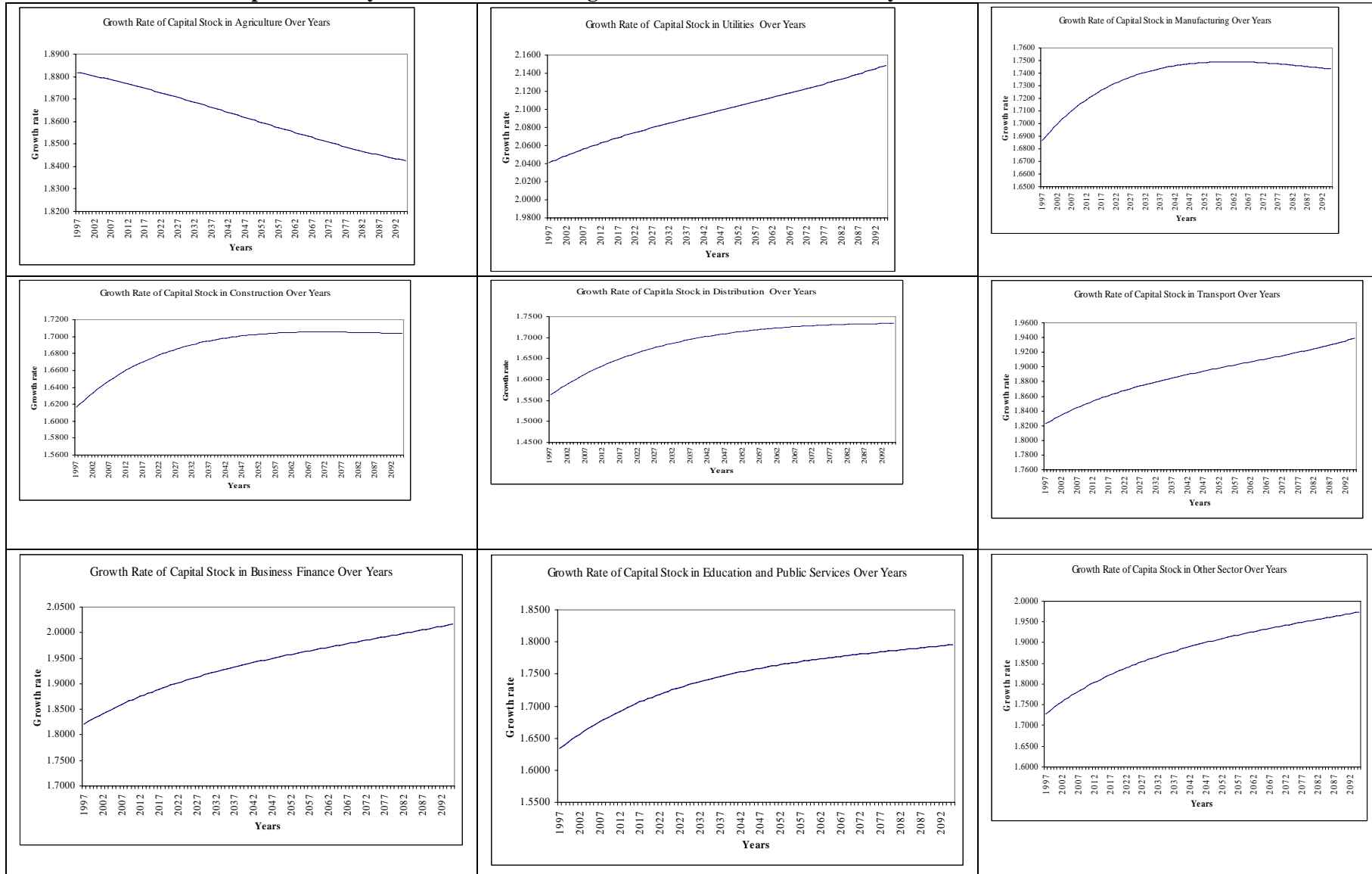
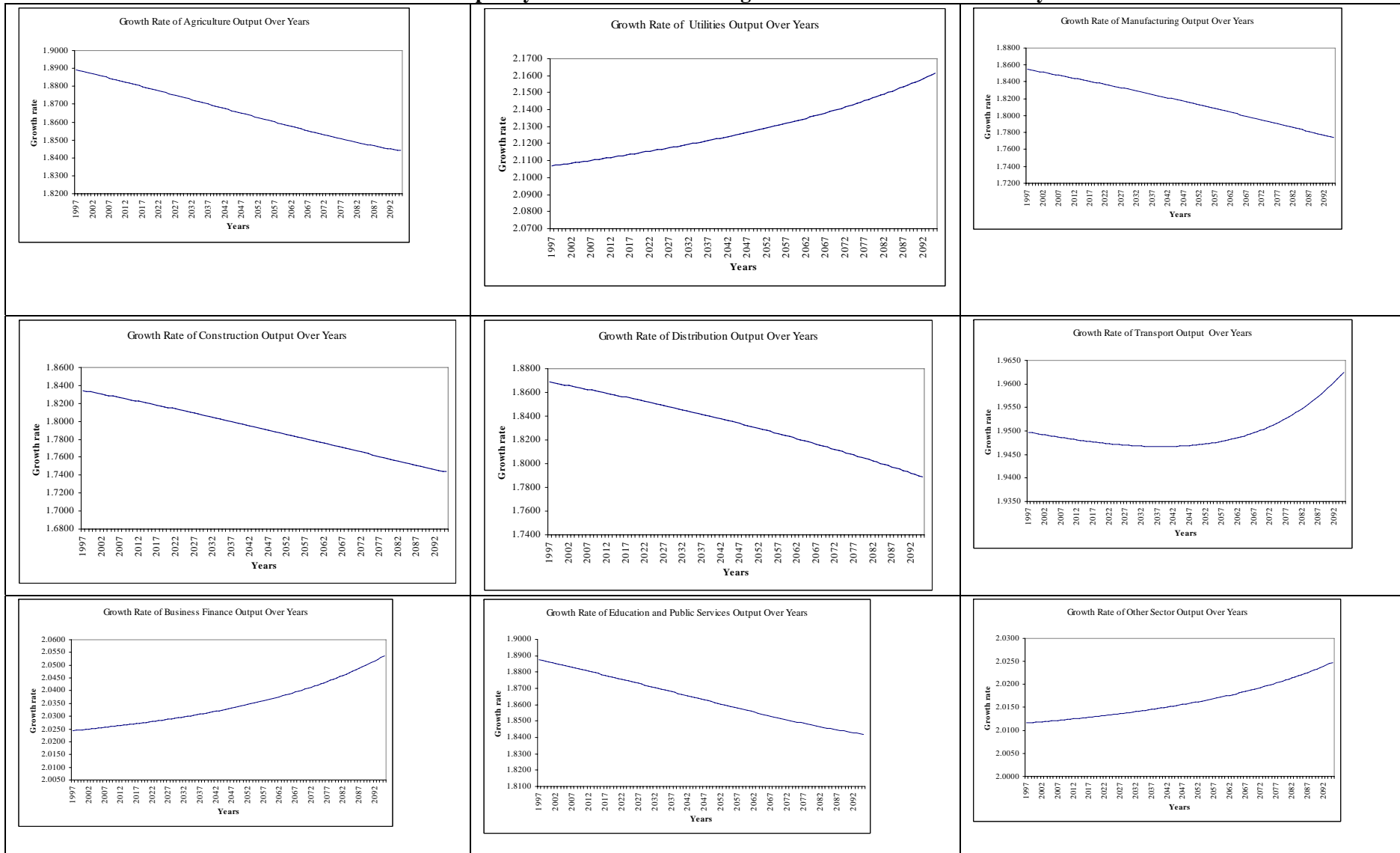


Figure 3
Growth Rates of Output by Sectors in Humber Region GE Model Over 21st Century



Conclusions of this study

- **First input output table for Humber Region: Hull, East Riding, North Lincolnshire and North East Lincolnshire**
- **First regional multisectoral general equilibrium model for Humber regions.**
- First dynamic model for Hull
- **Regional comparison is made for output, employment, capital and aggregate supply**
 - **dynamic growth paths are evaluated based on current preferences and technology for coming hundred years**
- Useful for policy analysis.
- Programmes and worksheets containing model are available.

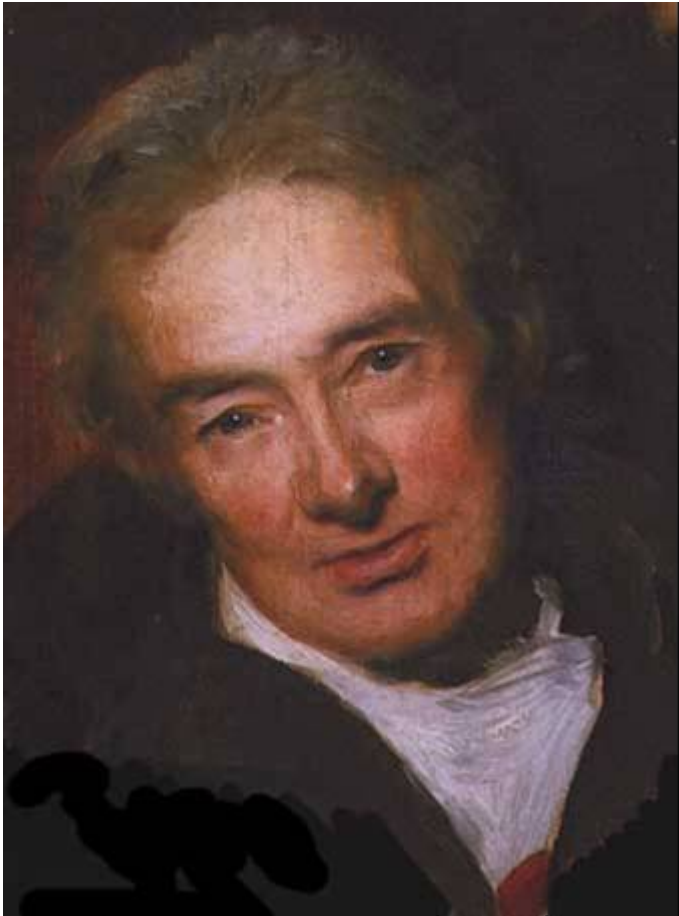
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