CAPITAL ACCUMULATION, GROWTH AND REDISTRIBUTION: GENERAL EQUILIBRIUM IMPACTS OF ENERGY AND POLLUTION TAXES IN UK

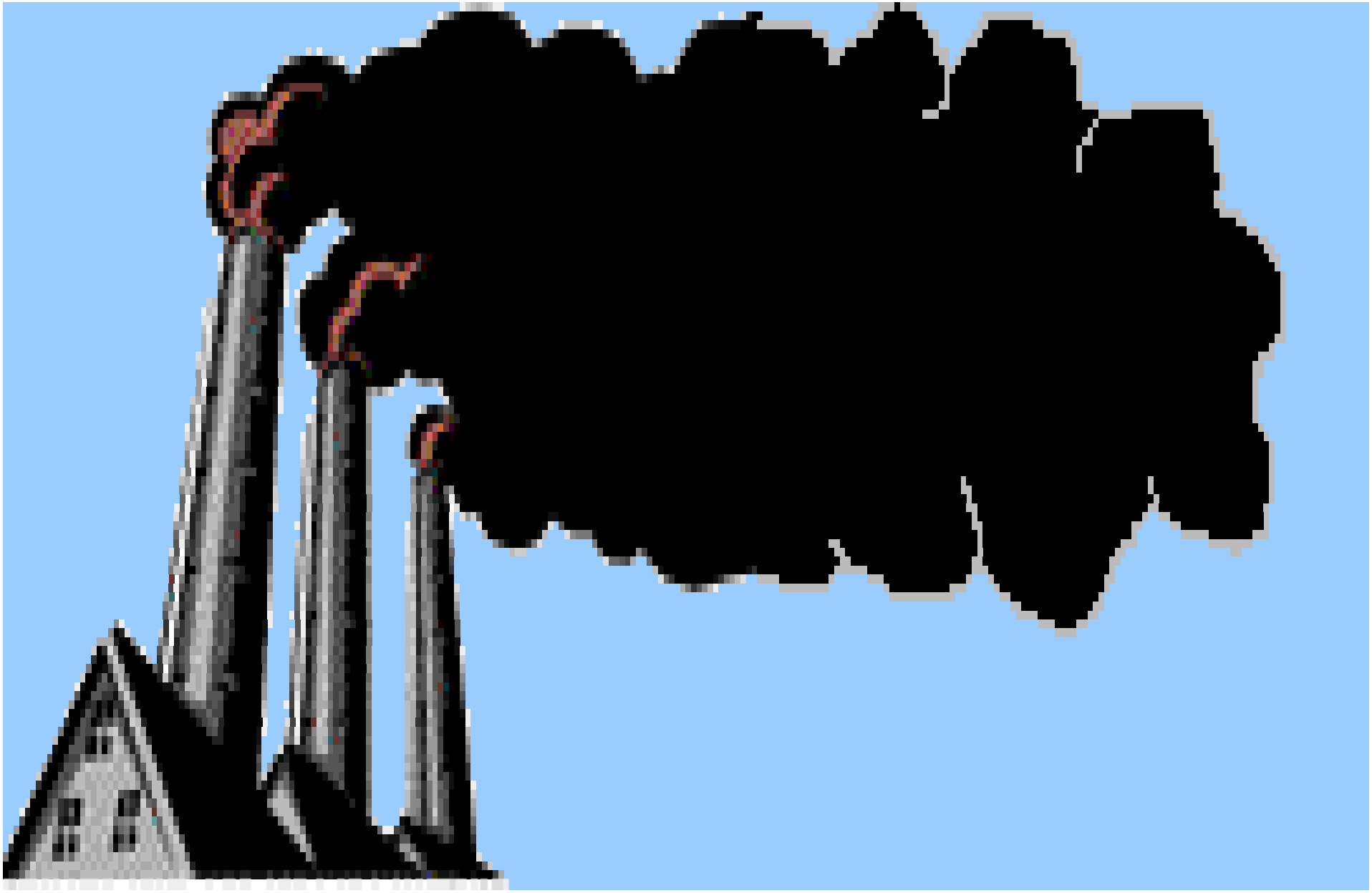
DR. Keshab Bhattarai

2006 South and South East Asia Econometric Society Meeting to be held in Chennai in December 18-20

THE UNIVERSITY OF HULL

Business School

Pollution as by Product of Production

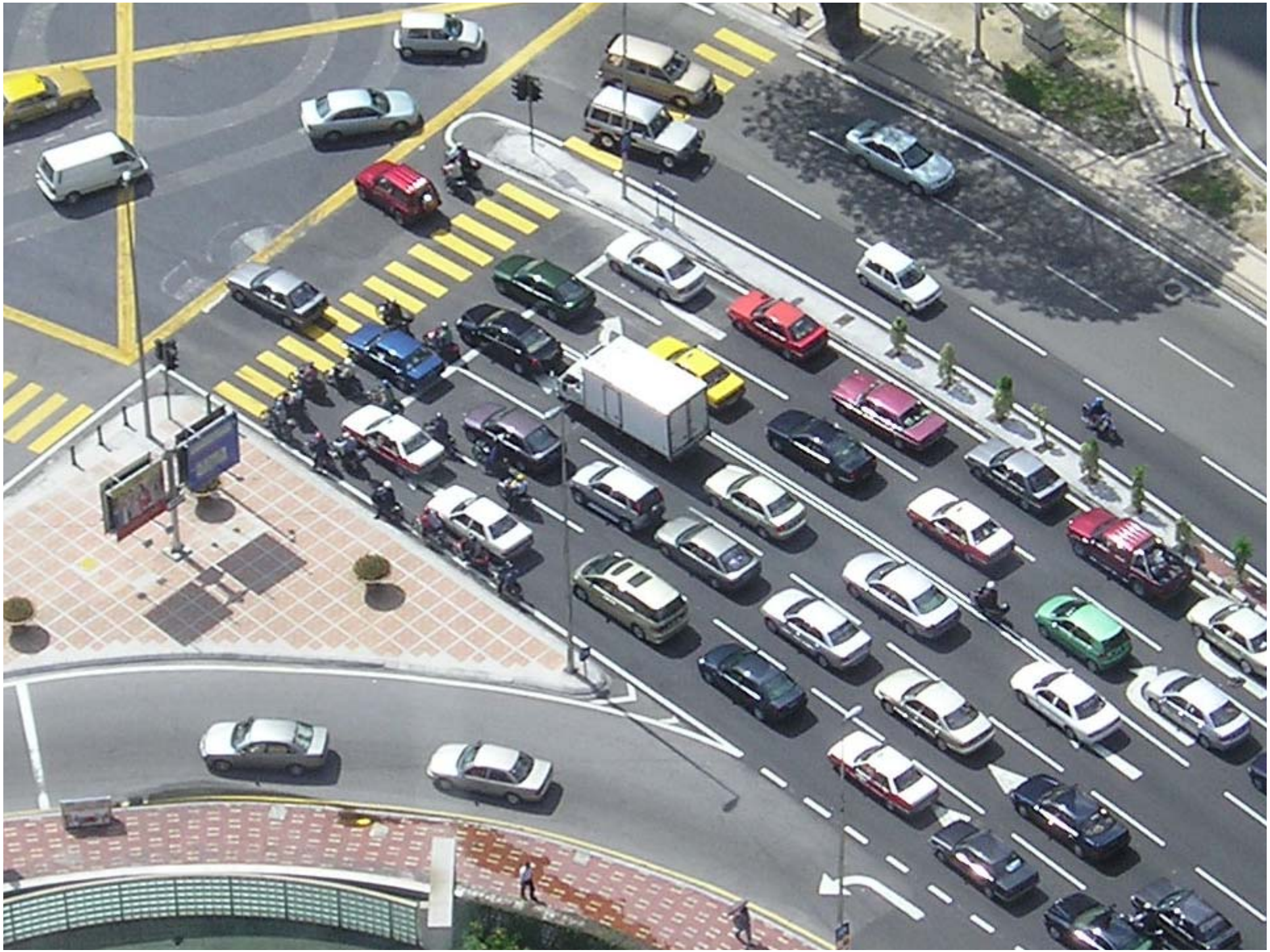


Electricity Generation and Pollution

Secondary industry: manufacturing

also includes oil refining, energy production, food processing


55A
ZD465



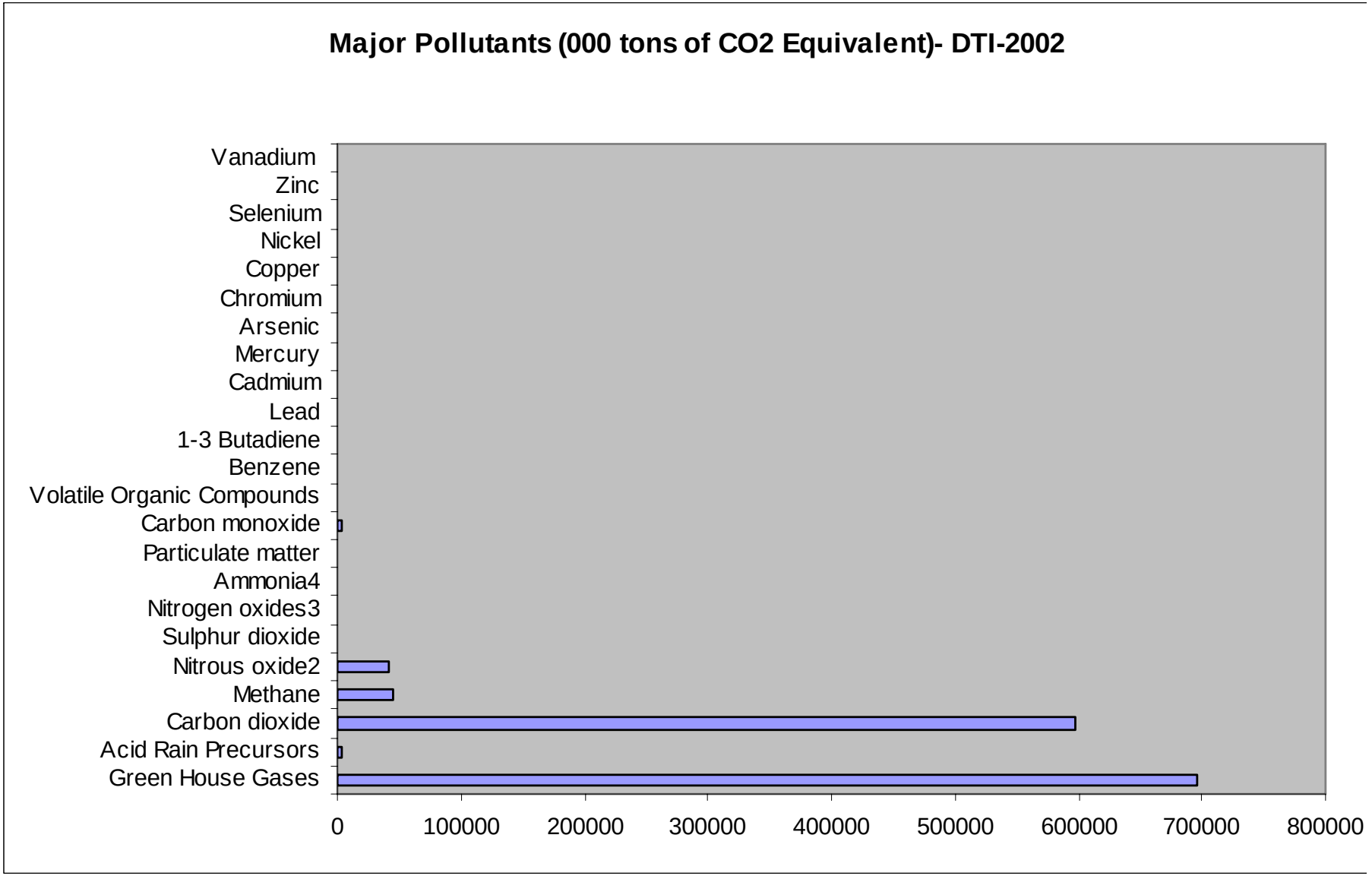

FRI
SAT
neer
14th Makar Sankranti
26th Republic Day
SECURITY EASTERN REG.
FINA
Bisle

Pollution of Natural Rivers

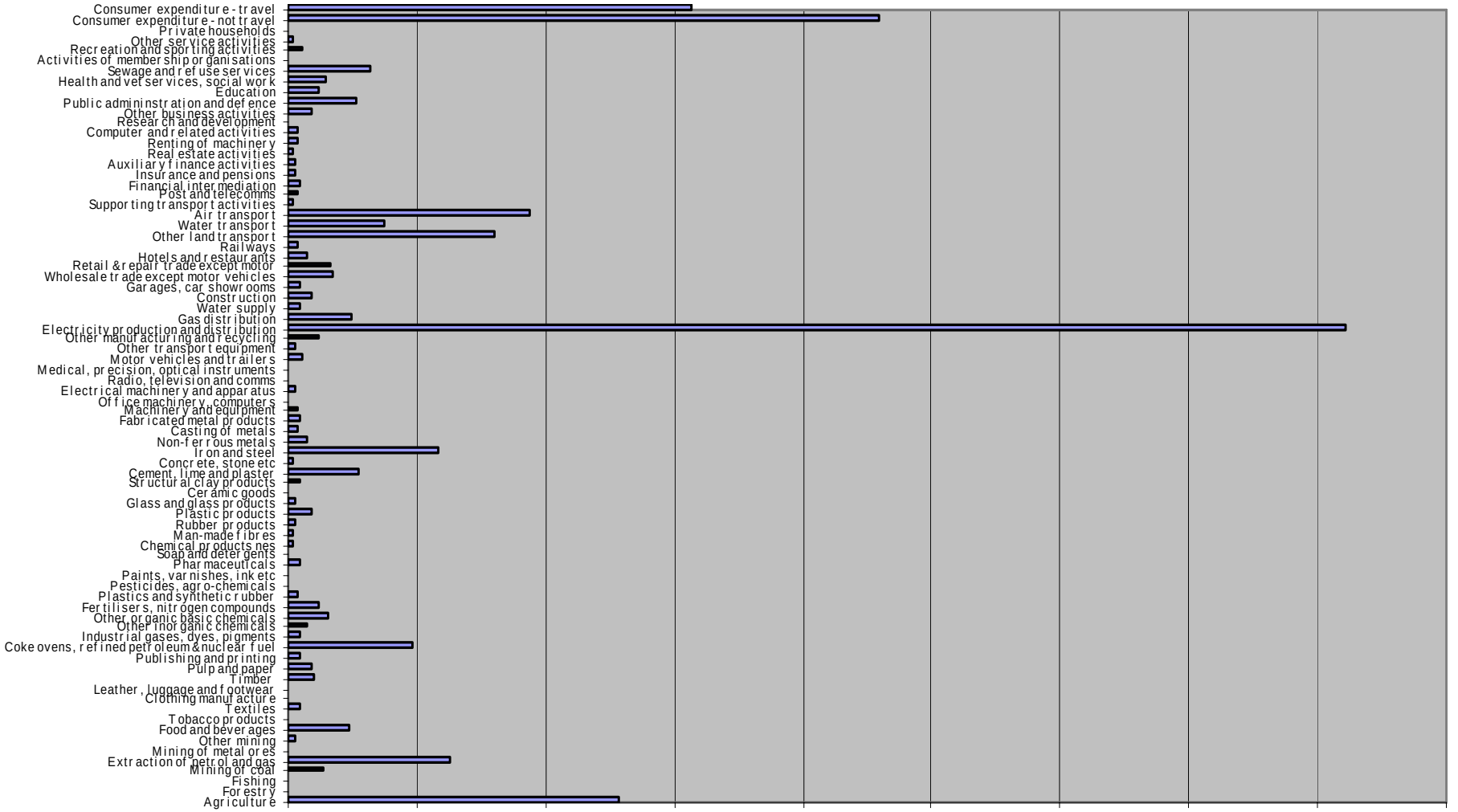
Chemical Pollution

Water Pollution

Toxic Wastes


Major Pollutants (000 tons of CO2 Equivalent)- DTI-2002
Vanadium
Zinc
Selenium
Nickel
Copper
Chromium
Arsenic
Mercury
Cadmium
Lead
1-3 Butadiene
Benzene
Volatile Organic Compounds
Carbon monoxide
Particulate matter
Ammonia4
Nitrogen oxides3
Sulphur dioxide
Nitrous oxide2
Methane
Carbon dioxide
Acid Rain Precursors
Green House Gases
0
100000
200000
300000
400000
500000
600000
700000
800000

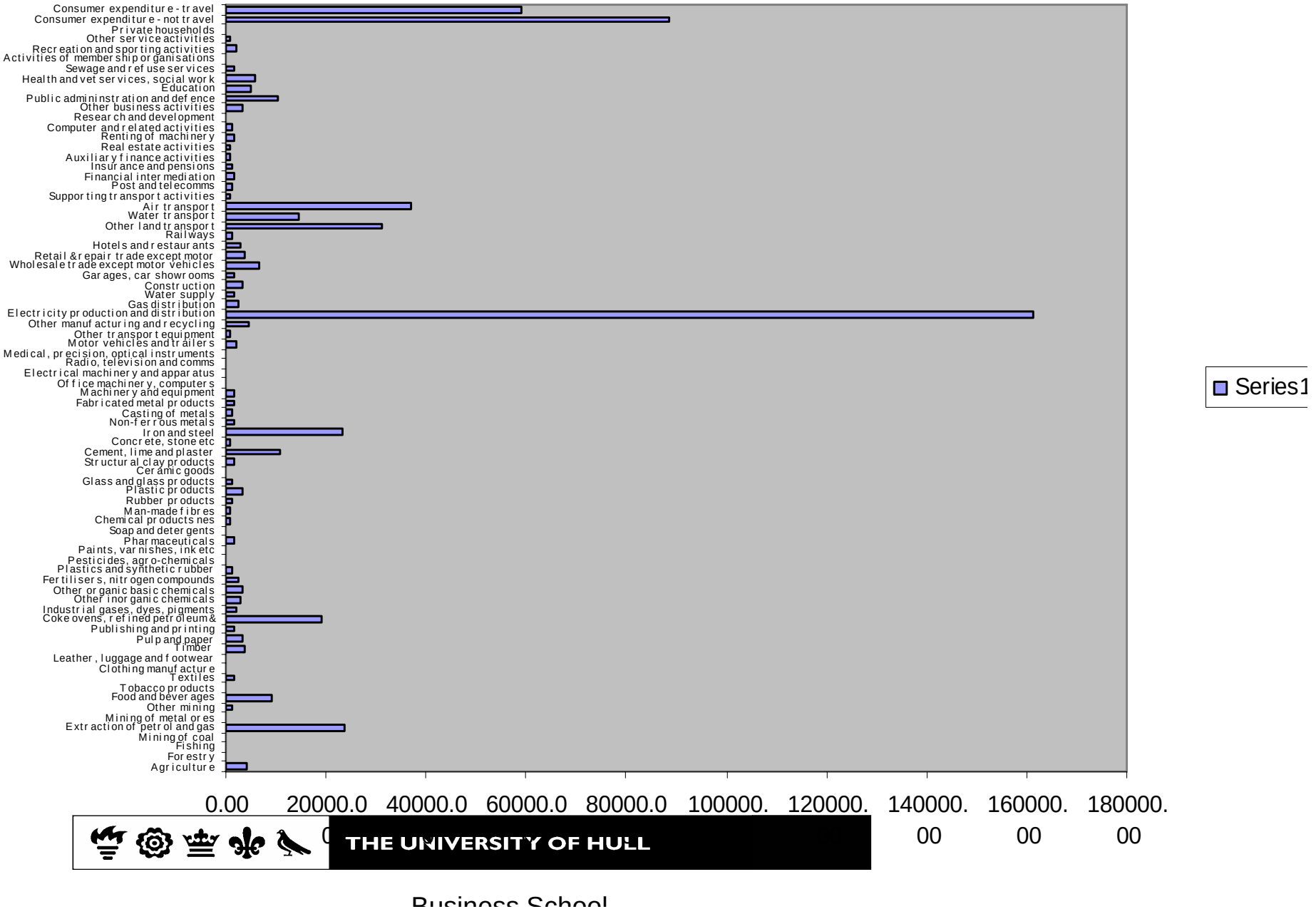
Green House Gases: Thousands of Tonnes of CO2, DTI-2002
(CO2, CH4, N2O, HFC, PFC, SF6)



THE UNIVERSITY OF HULL

Business School

Carbon Emission in Production (000 tonnes)



Some Literature on Growth, General Equilibrium, Energy and Environment

How man made factors enhance economic growth:

Maddison (1991), Ramsey (1928), Hicks (1937), Harrod (1939), Domar (1947), Solow (1956), Kaldor (1961), Uzawa (1962) Cass (1965), Koopmans (1965), Lucas (1988), Romer (1989), Parente (1994), Perroni (1995), Sargent and Ljungqvist (2005)

Multisectoral dynamic real economy models

Auerbach and Kotlikoff (1987), Rutherford (1995), Kehoe, SriNivashan and Whalley (2005). Leontief (1949), Harberger (1962), Jorgensen (1961) Ballard-Fullerton-Shoven-Whalley (BFSW(1985)), and Robinson (1991), Fullerton and Rogers (1993), Mercenier and Srinivasan (1994) and Dixon et al. (1992) had mainly relied in the comparative static framework

Partial or general equilibrium models with the electricity sector to examine how pollution arises in process of generating energy required for efficient functioning of the economy:

Bohringer and Rutherford (2004) Grubb (2004) Green and Newbery (1992), Manne and Richel (1992), McFarland, Reilly and Herzog (2002) Nordhaus (1979), Perroni and Rutherford (1993), Backus and Crucini (2000), Boyd and Doroodian (2001), Coupal and Holland (2002), Grepperud and Rasmussen (2004), Jansen and Klaassen (2000), Kumbaroglu (2003), Spear(2003) and Thompson (2000)

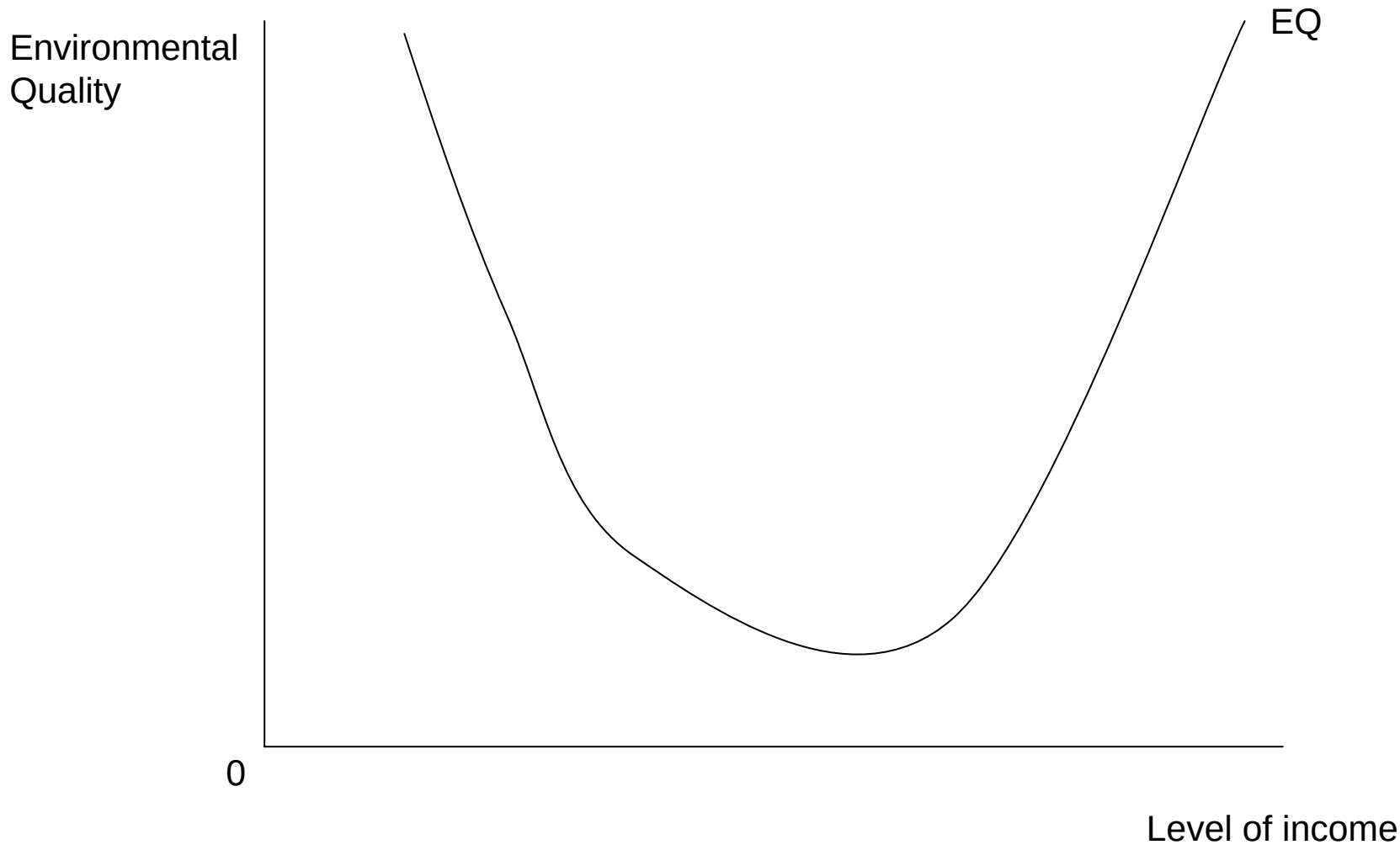
Climate change and burden and dividend sharing from improvement of environment:

Aronsson, (1999), Bohringer and Conrad and Loschel (2003), Crettez and Aronsson (1999), Crettez (2004) Dissou, Mac Leod, and Souissi (2002), Faehn and Holmoy (2003) Nordhaus and Yang (1996), Proost and Van Regemorter (1992), Rasmussen (2001), Kumbaroglu (2003), Roson (2003) , Uri and Boyd (1996) and Vennemo (1997)

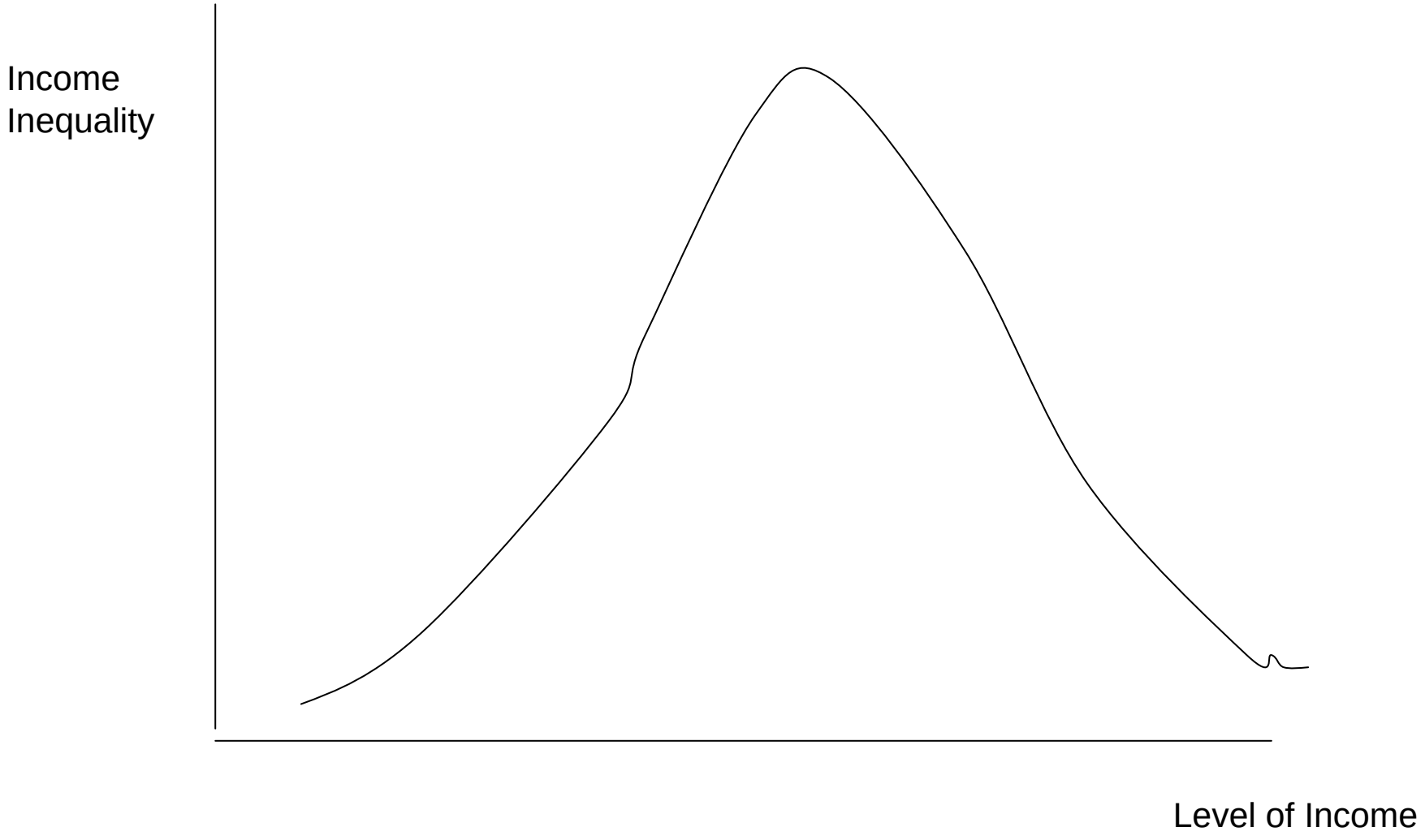
Game Theoretic models: Radner et. al.

DEFRA Report (various years), Kyoto Protocol (1997), Glenn Eagle summit (2005), Stern Report (2006)

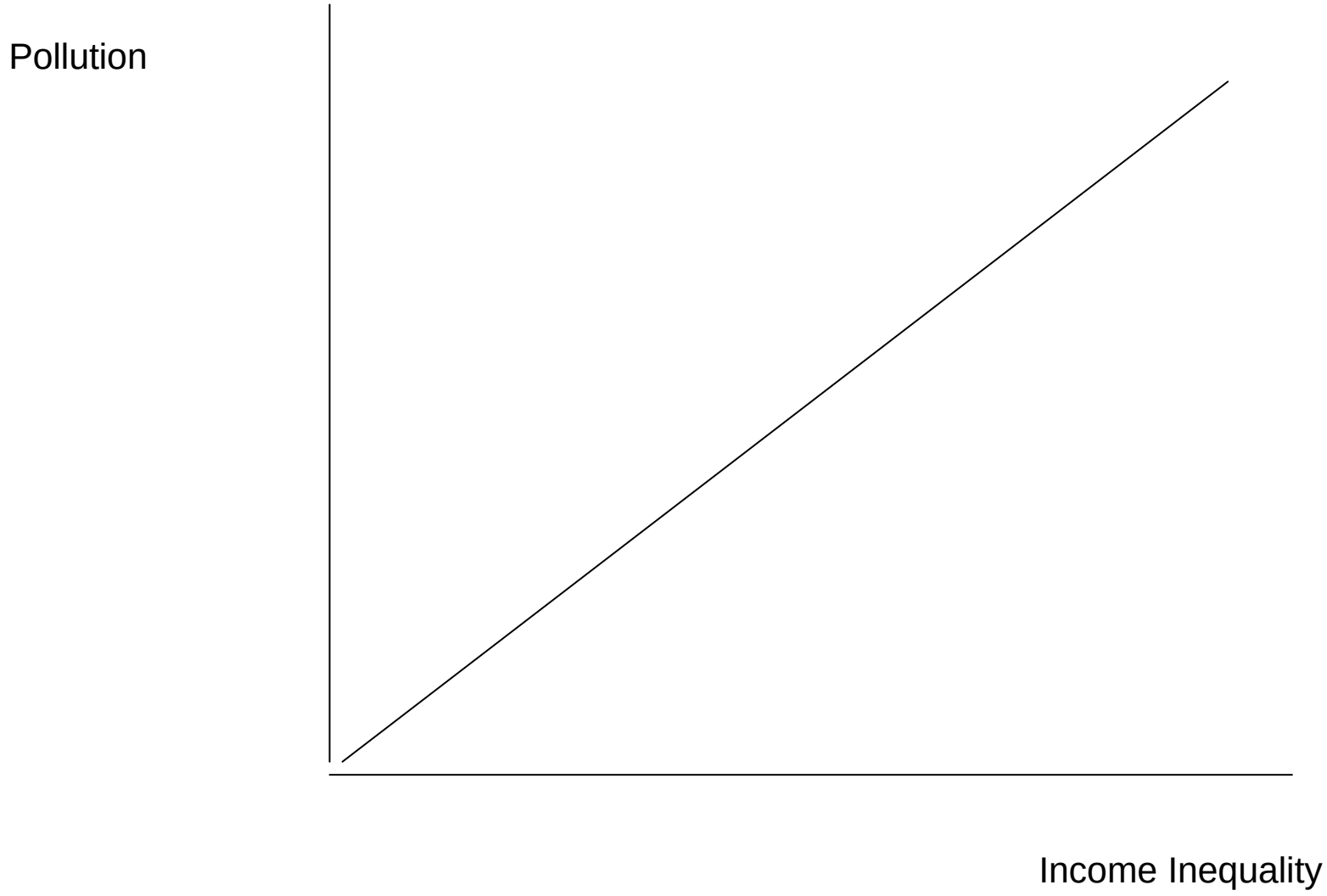
Environmental Quality and Level of Income



Income Inequality and Level of Income



Pollution and Income Inequality

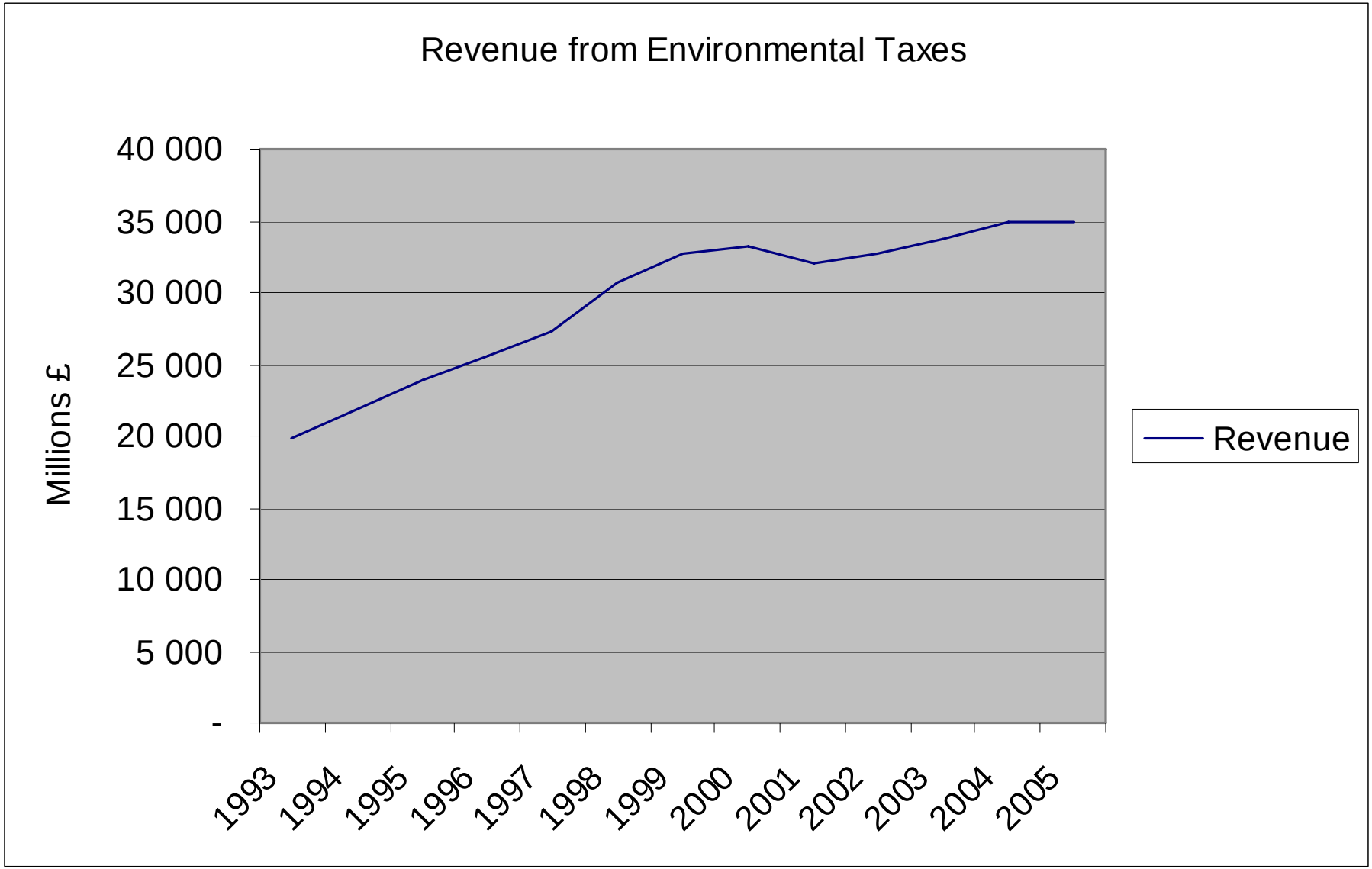


Major Findings of Stern Review (2006)

- Greenhouse gases major causes of global warming
- Rise in the mean global temperature by 2-5 centigrade likely by 2030
- Draughts and floods
- Oceanic, atmospheric imbalances, melting of Ice Sheets and rise in sea level by 5-12 m

EU and UK Targets: Stern Review (2006)

- Kyoto Agreement
- Eco-Driving: 120 g CO2 per KM by 2012
- Revenue neutral road pricing Scheme
- Reducing energy consumption by 80 percent by 2020
- Energy saving buildings
- Ships powered by sun, wind, waves, and fuel cells
- Raising the ratio of renewable to 20 percent of total energy sources by 2020

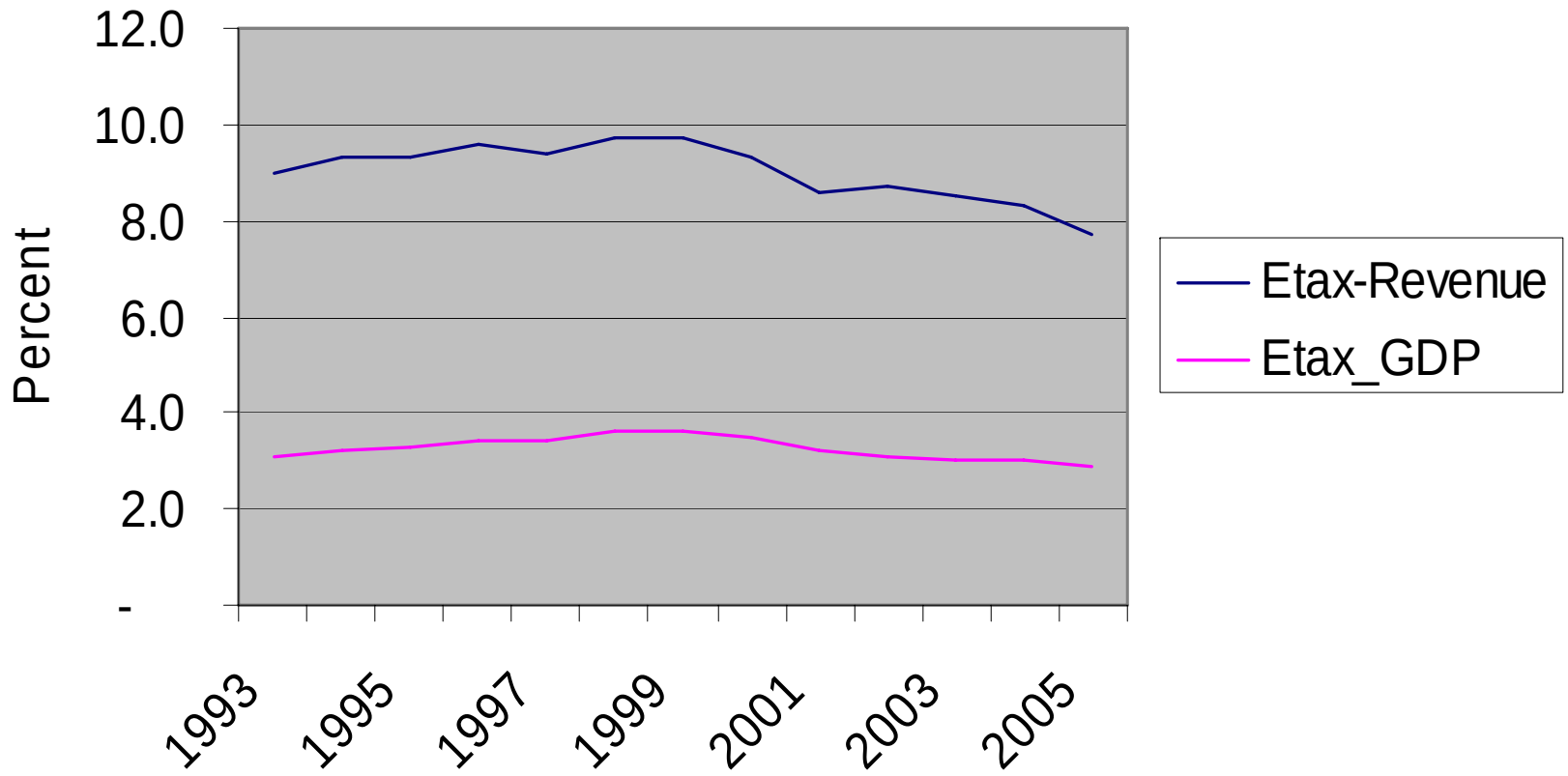


THE UNIVERSITY OF HULL

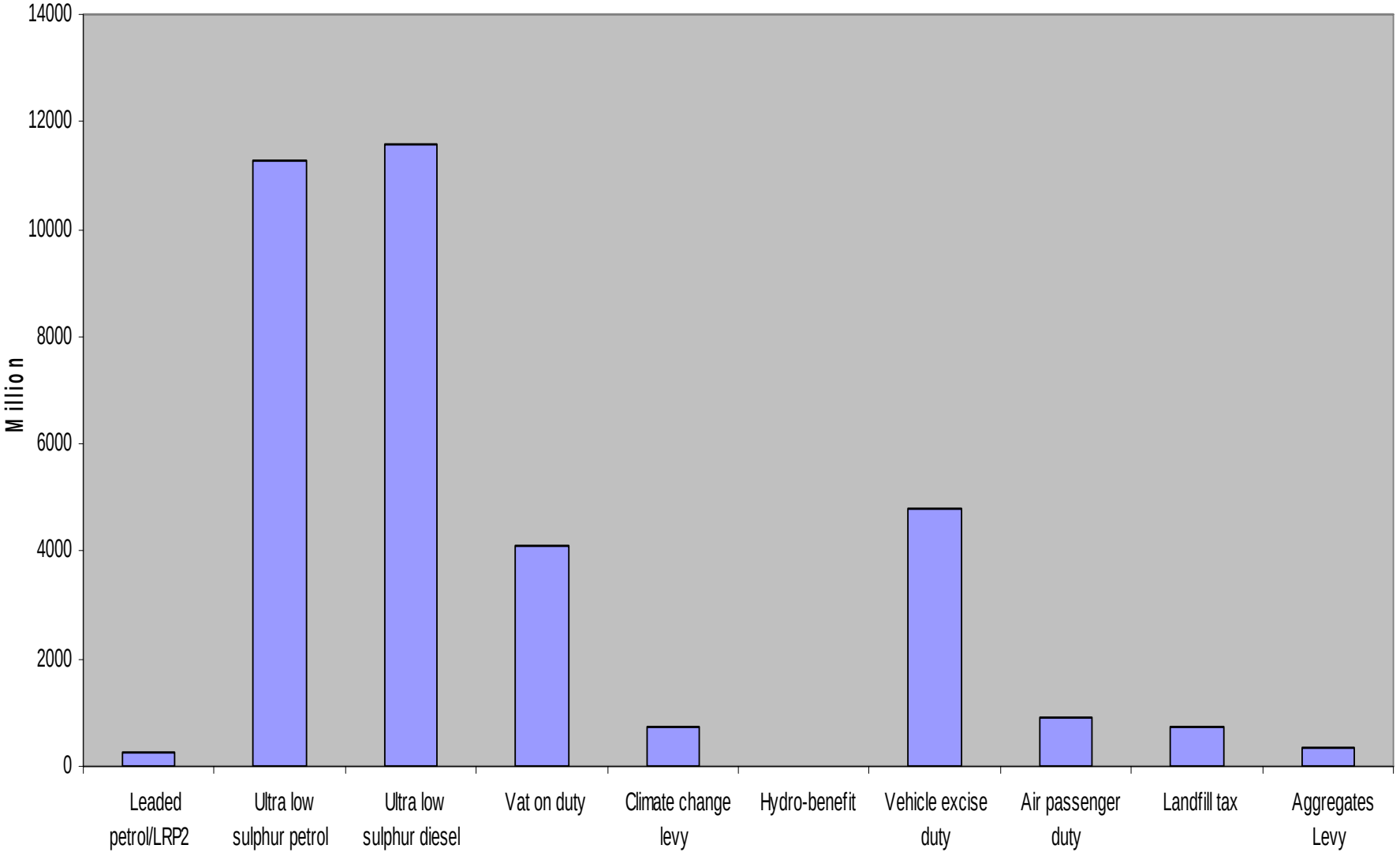
Business School

Ratios of Environmental Tax to Total Revenue and GDP in UK

(Source: http://www.statistics.gov.uk/statbase/Product.asp?vlnk=3698)



Revenue from Environmental Taxes, 2005



Major Arguments for Policy Analysis

- Pollution taxes on the use of capital and labour inputs in production across sectors link the energy, environment and growth of economy.
- Air, water, land pollution is essentially a by-product of processes of production.
- Evolution of economy differs with and without energy and pollution taxes.
- Dynamic micro impacts on output, employment, investment and capital stocks by sectors and households at micro level.
- Dynamic macro impacts on growth and redistribution.
- Environmental taxes slow down the growth of economy.
- Mechanism of pollution control should rely on energy saving or energy efficiency measures than on the energy and environmental taxes.

Environment in Ramsey Model for Optimal Growth

Preference: $U_0 = \sum_{t=0}^{\infty} \beta^t \ln(C_t) - \sum_{t=0}^{\infty} \theta^t \ln(E_t) \quad 0 < \beta < 1$

Technology: $Y_t = AK_t^{\alpha} \quad 0 < \alpha < 1 \quad A = 1$

Emission $E_t = \varphi Y_t \quad 0 < \varphi < 1$

Market clearing: $C_t + I_t = Y_t \quad K_0 = K_0 \quad C_t = Y_t - I_t$

Accumulation $K_{t+1} = K_t(1-\delta) + I_t$

Cost of pollution in production reflected in lower investment

State and control: $C_t = AK_t^{\alpha} - \phi\{K_{t+1} - K_t(1-\delta)\}$

$0 < \phi < 1$

Ramsey (1928) Cass (1965) Koopman(1965) Uzawa (1965)

Optimal Conditions and Steady State of the Model

$$\underset{K}{Max}\, U_0 = \sum_{t=0}^{\infty} \beta^t \ln\left(K_t^{\alpha} - K_{t+1} + K_t(1-\delta)\right) - \sum_{t=0}^{\infty} \theta^t \varphi K_t^{\alpha}$$

$$\frac{\partial U_t}{\partial C_t}\frac{\partial C_t}{\partial C_{t+1}}\frac{\partial C_{t+1}}{\partial K_{t+1}} = .. - \frac{\beta^t}{C_t}\left(\alpha K_t^{\alpha-1} - 1\right) + \frac{\beta^{t+1}}{C_{t+1}} - \theta\varphi\alpha K_t^{\alpha-1} + .. = 0$$

$$.. = K_{t-1} = K_t = K_{t+1} = .. = \overline{K}$$

$$.. = C_{t-1} = C_t = C_{t+1} = .. = \overline{C}$$

$$\frac{\beta^t}{C_t}\alpha K_t^{\alpha-1} - \theta\varphi\alpha K_t^{\alpha-1} = \frac{\beta^{t+1}}{C_{t+1}} - \frac{\beta^{t+1}(1-\delta)}{C_{t+1}}$$

Pollution reduces output and capital stock in the steady state

$$\bar{K} = \left(\frac{\frac{\beta}{\bar{C}} - \frac{\beta(1-\delta)}{\bar{C}}}{\alpha\left(\frac{\beta}{\bar{C}} - \alpha\theta\varphi\bar{C}\right)} \right)^{\alpha-1}$$

$$\frac{\partial \bar{K}}{\partial \theta} < 0, \frac{\partial \bar{K}}{\partial \varphi} < 0 \quad \frac{\partial \bar{Y}}{\partial \theta} < 0, \frac{\partial \bar{Y}}{\partial \varphi} < 0$$

Model Structure

Households

$$\text{Max } U_0^h = \sum_{t=0}^{\infty} \beta^t U_t^h\left(C_t^h, l_t^h\right) - \sum_{t=0}^{\infty} \psi EM_t^h \tag{1}$$

Subject to

$$\sum_{t=0}^{\infty} R_t^{-1}\left[P_t(1+t^{vc})C_t^h + w_t(1-t_l)l_t^h + PP_t EM_t^h\right] = \sum_{t=0}^{\infty}\left[(1-t_l)w_t L_t^h + (1-t_k)r_t K_t^h + TR_t^h\right] \tag{2}$$

Firms

$$\Pi_{j,t}^y = [((1-\delta_i^e)PD_{i,t}^{\frac{\sigma_y-1}{\sigma_y}} + \delta_i^e PE_{i,t}^{\frac{\sigma_y-1}{\sigma_y}})]^{\frac{1}{\sigma_y-1}} - \theta_j^v PY_{j,t}^v - \theta_j^d \sum_i a_{i,j}^d P_{i,t} \tag{3}$$

Government

$$REV_t = \sum_{i,h} t_i^k r_t K_{i,t} + \sum_i t_i^{vc} P_{i,t} C_{i,t}^h + \sum_i t_i^{vg} P_{i,t} G_{i,t} + \sum_i t_i^{vk} P_{i,t} I_{i,t} + \sum_{i,h} t_l wLS_t^h + \sum_i t_i^m PM_{i,t} M_{i,t} + \sum_i t_i^p P_{i,t} GY_{i,t} \tag{4}$$

Environment

$$EMIS_t = \sum_i \phi_i Y_{i,t} \tag{5}$$

Benchmarking

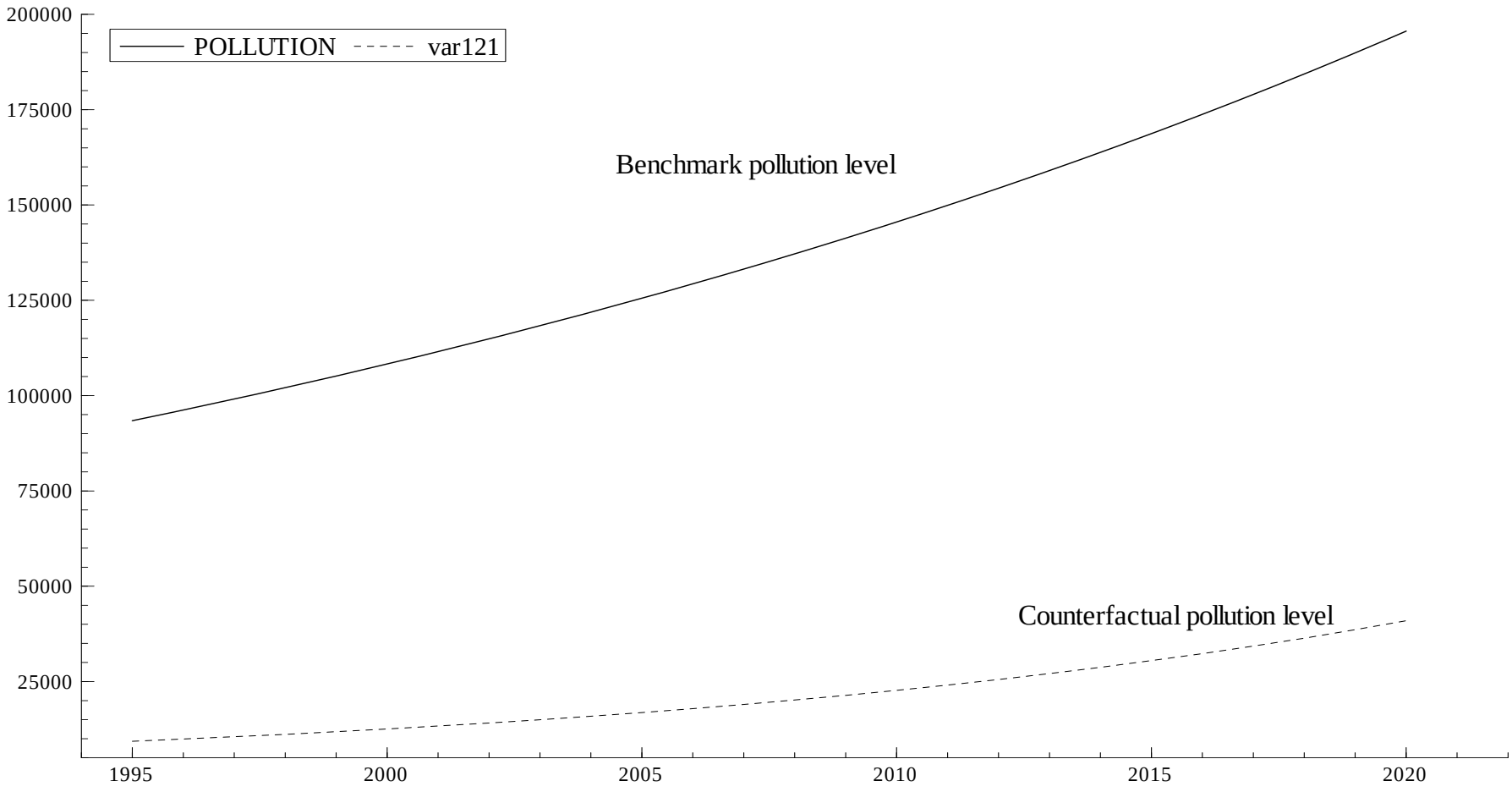
$$P_t^k = R_t^t + (1-\delta)P_{t+1}^k \tag{6}$$

$$R_t^t = (r+\delta)P_t = (r+\delta)P_{t+1}^k \tag{7}$$

$$\frac{P_{t+1}^k}{P_t^k} = \frac{1}{1+r} \approx 1-\delta\,. \tag{8}$$

$$\overline{V}_i = (r+\delta_i)P_{t+1}^k K_i, \text{ or} \qquad K_i = \frac{\overline{V}_i}{(r+\delta_i)} \qquad \text{Since } P_t = P_{t+1}^k = 1 \tag{9}$$

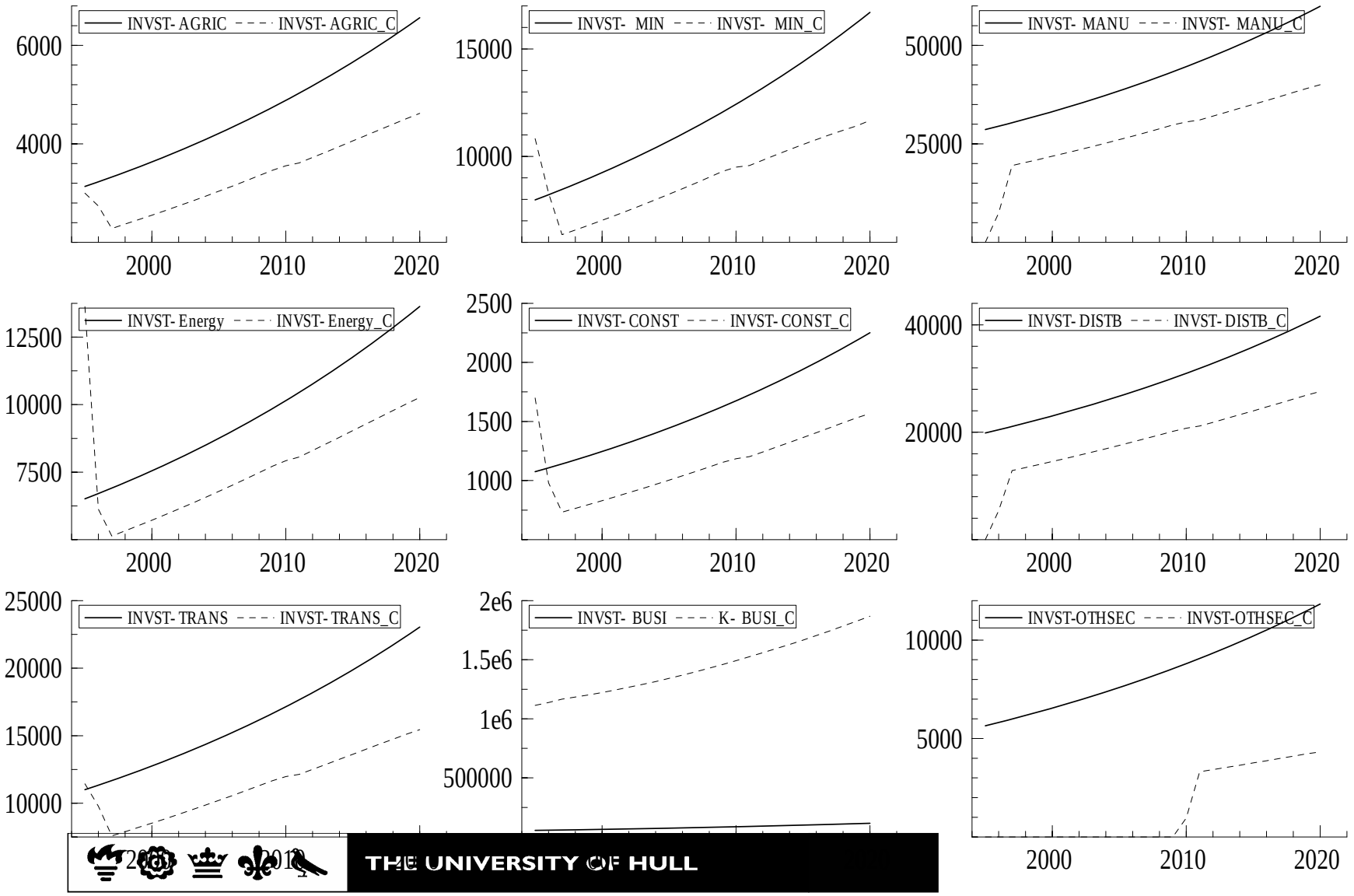
$$I_i = \frac{(g_i+\delta_i)}{(r+\delta_i)}\overline{V}_i \tag{10}$$



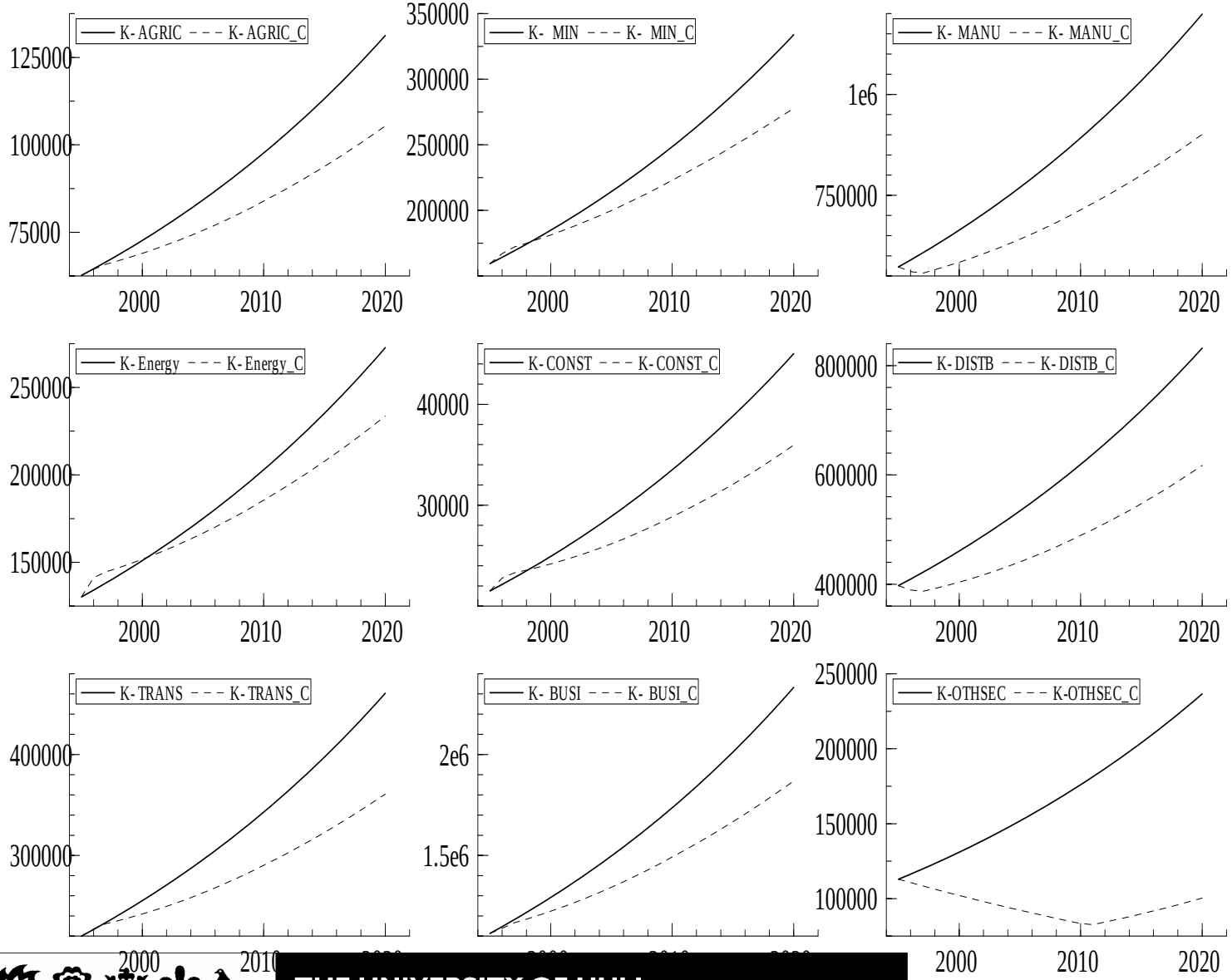
THE UNIVERSITY OF HULL

Business School

Impact of energy carbon taxes on investment by sectors



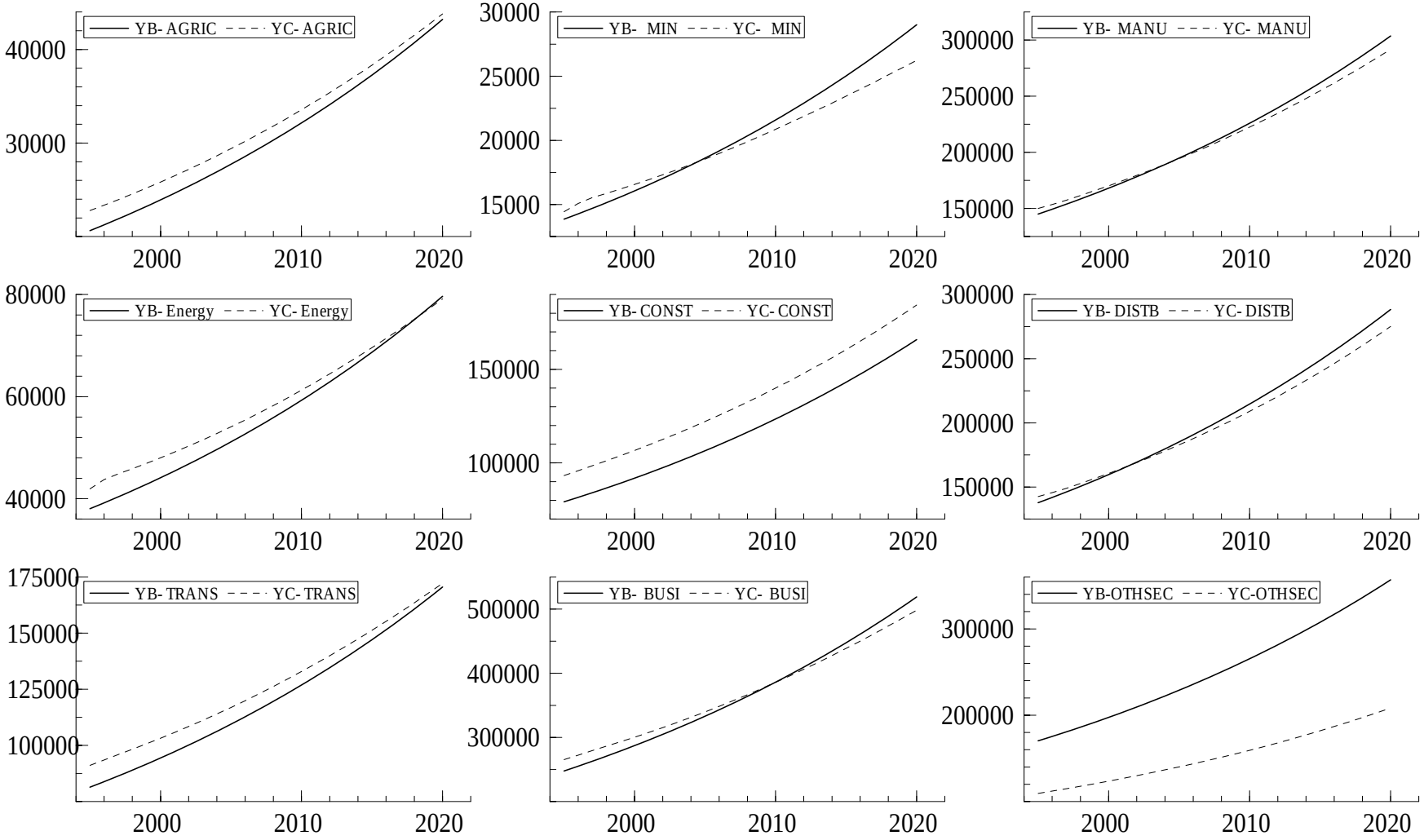
Impact of carbon energy taxes in capital stock by sectors



THE UNIVERSITY OF HULL

Business School

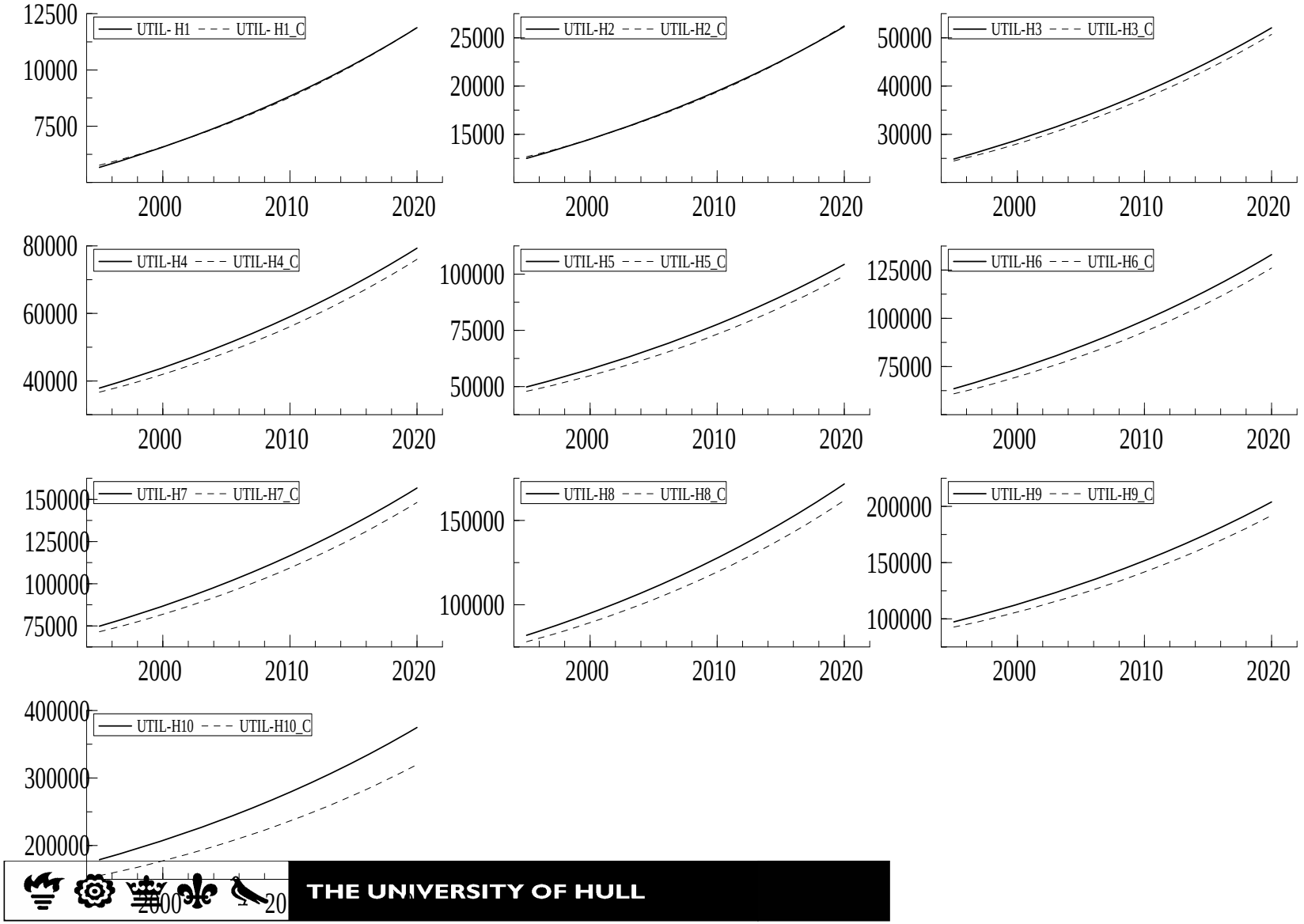
Impact of carbon energy taxes in the levels of output by sectors



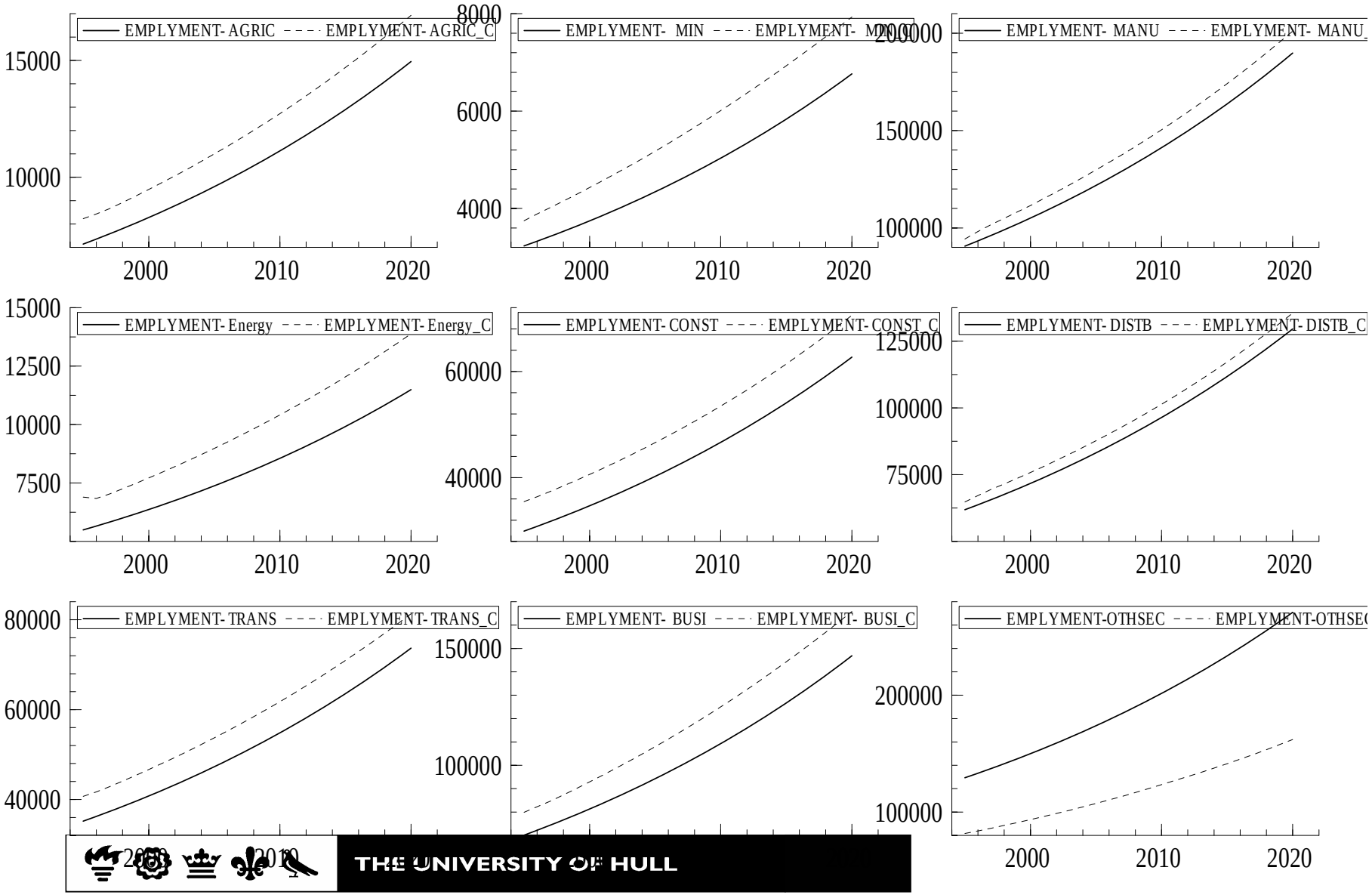
THE UNIVERSITY OF HULL

Business School

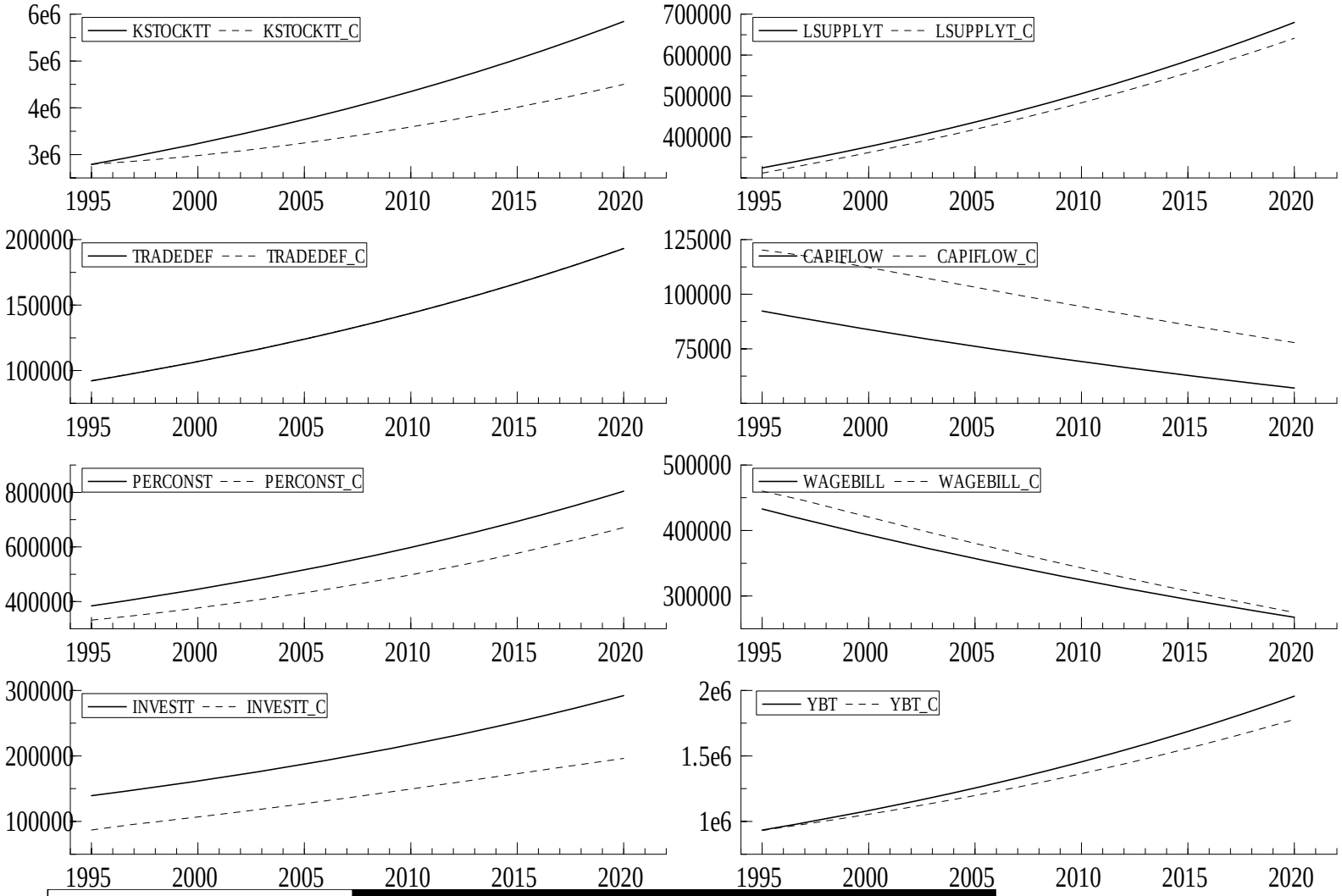
Impact of carbon energy taxes in utility level of households



Impact of energy carbon taxes on employment by sectors



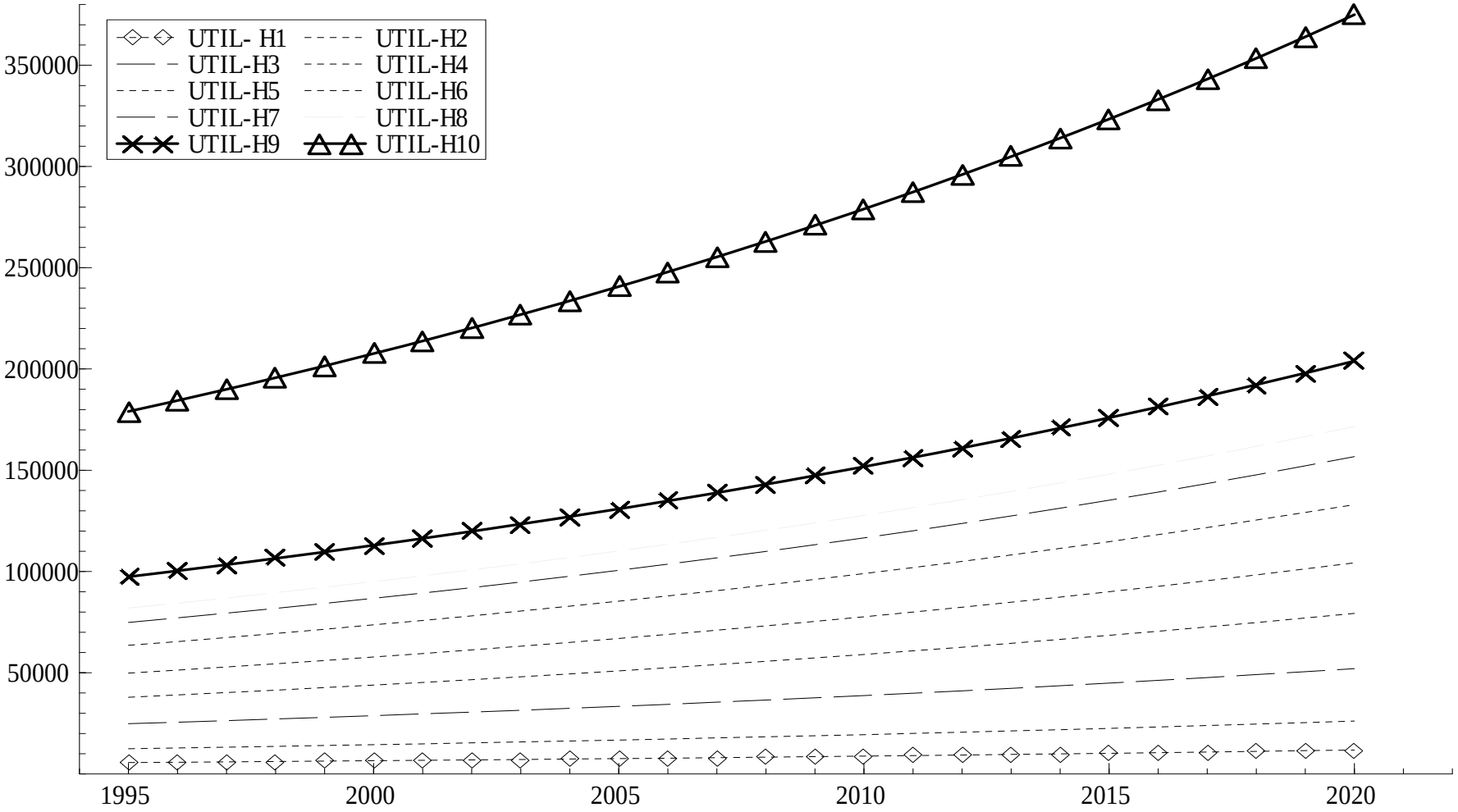
Macroeconomic impacts of carbon energy taxes



THE UNIVERSITY OF HULL

Business School

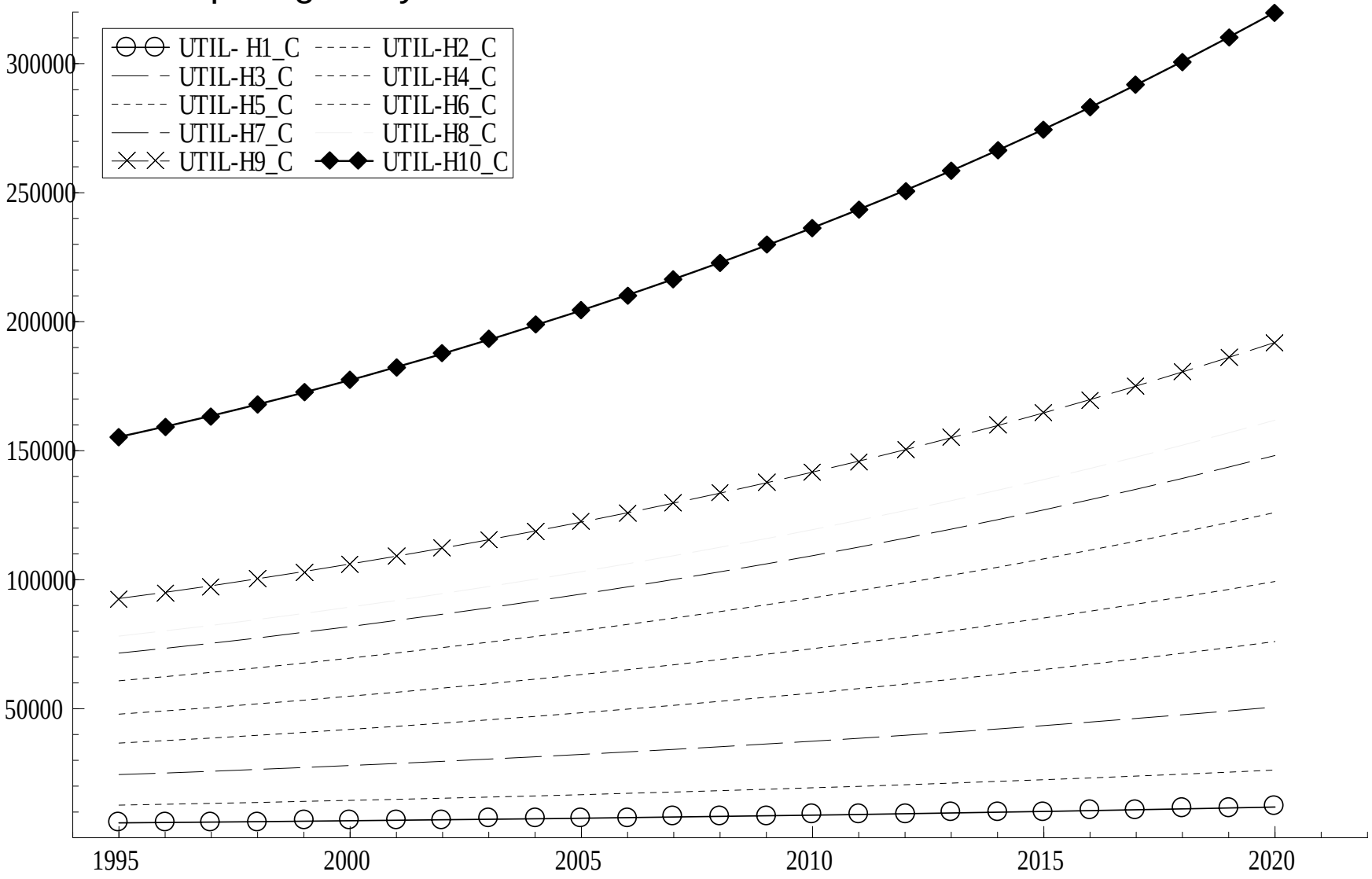
Utility Level of Households in the Benchmark Scenario



THE UNIVERSITY OF HULL

Business School

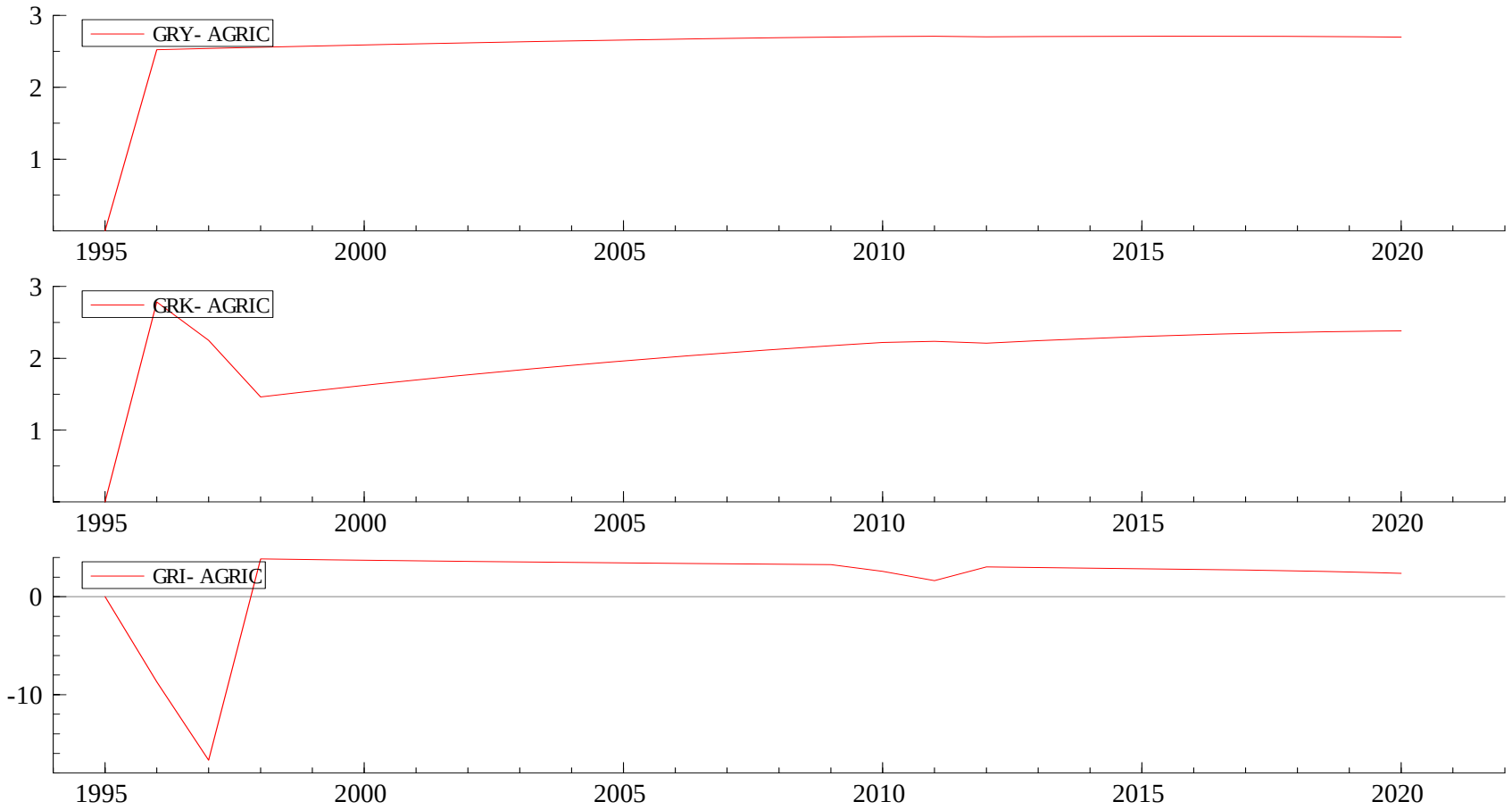
Comparing Utility Level All Households in Counterfactual Scenario



THE UNIVERSITY OF HULL

Business School

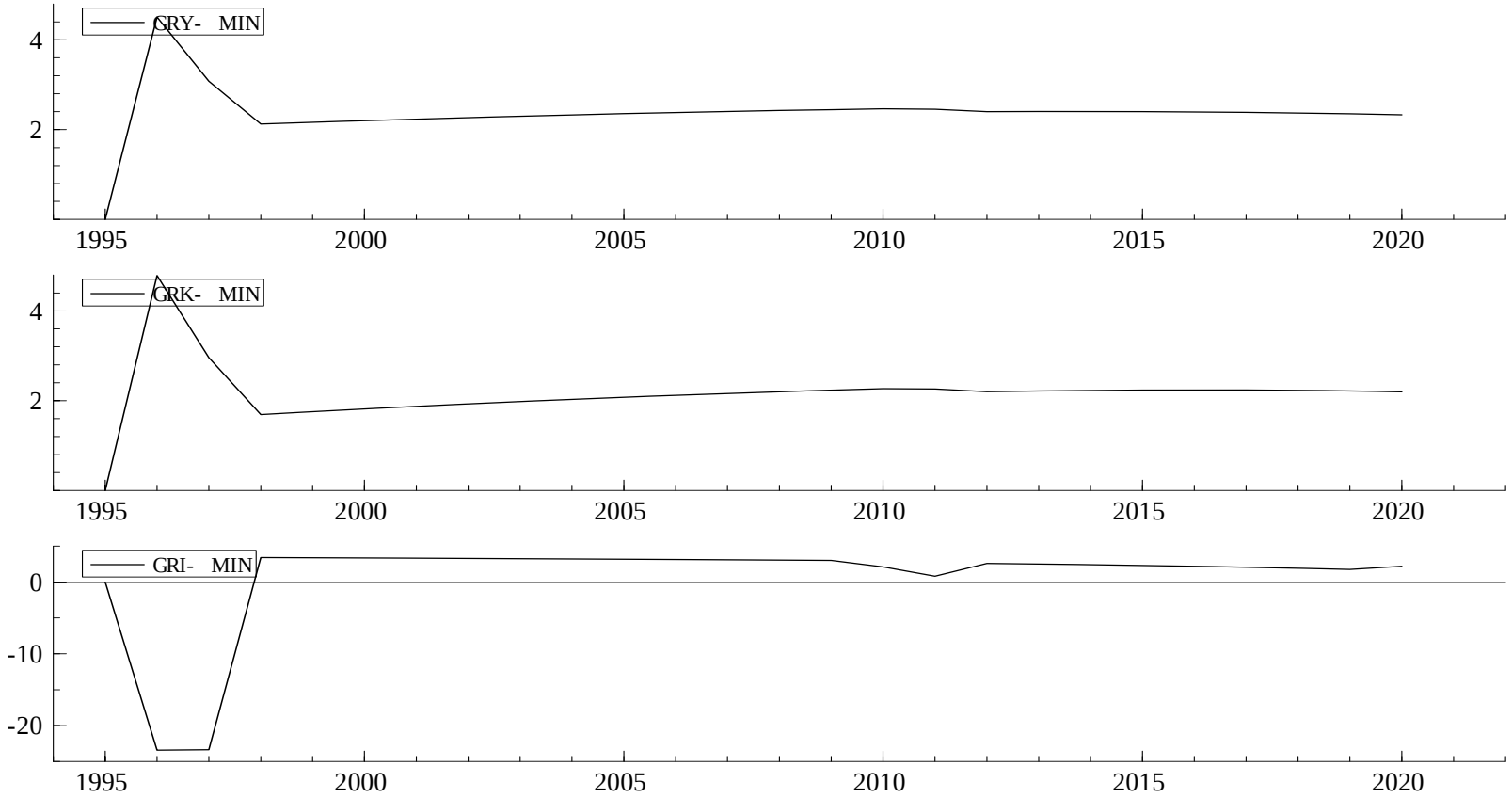
Growth rate of output, investment and capital stock in agriculture.



THE UNIVERSITY OF HULL

Business School

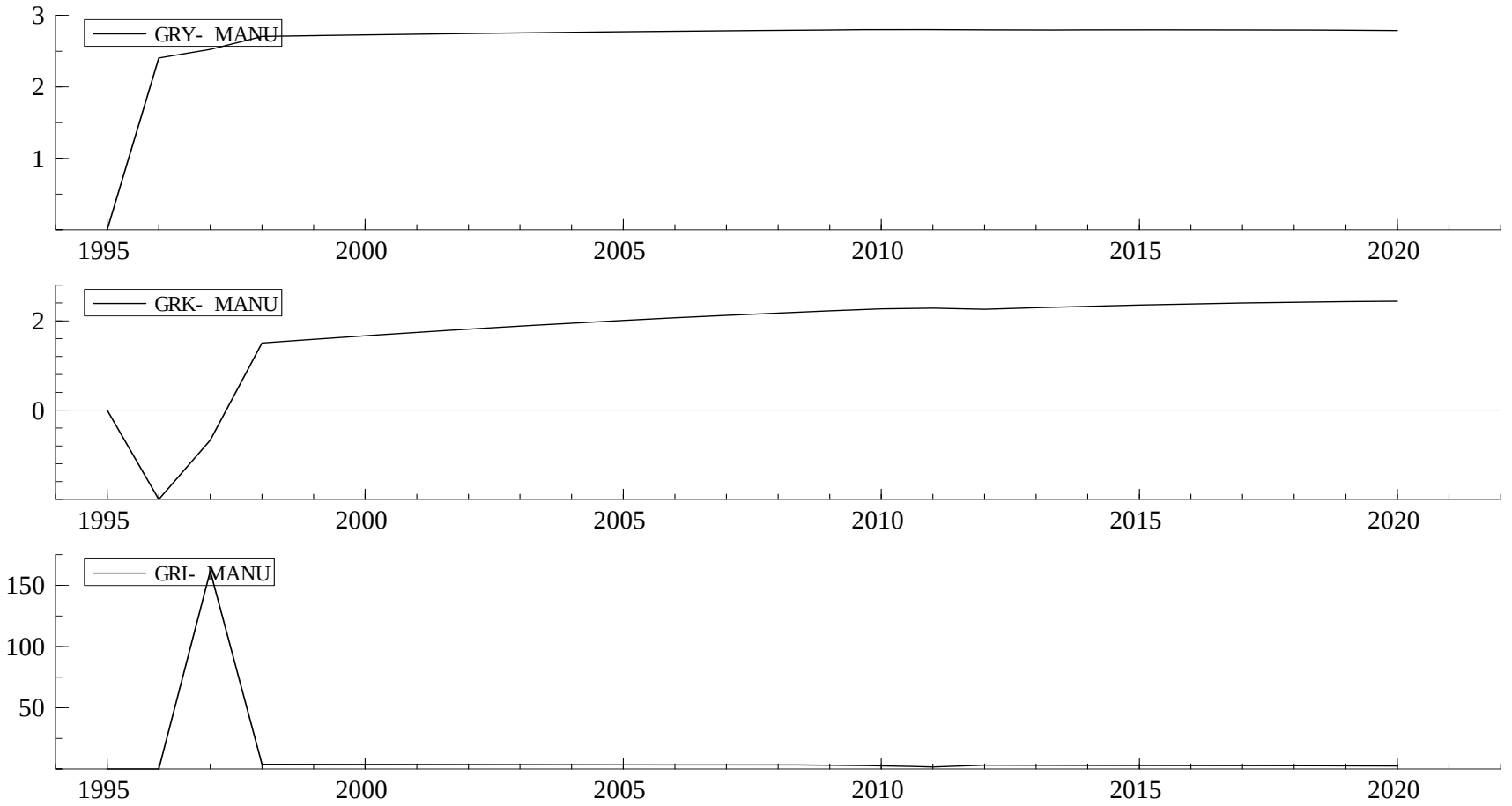
Growth rate of output, investment and capital stock in mining



THE UNIVERSITY OF HULL

Business School

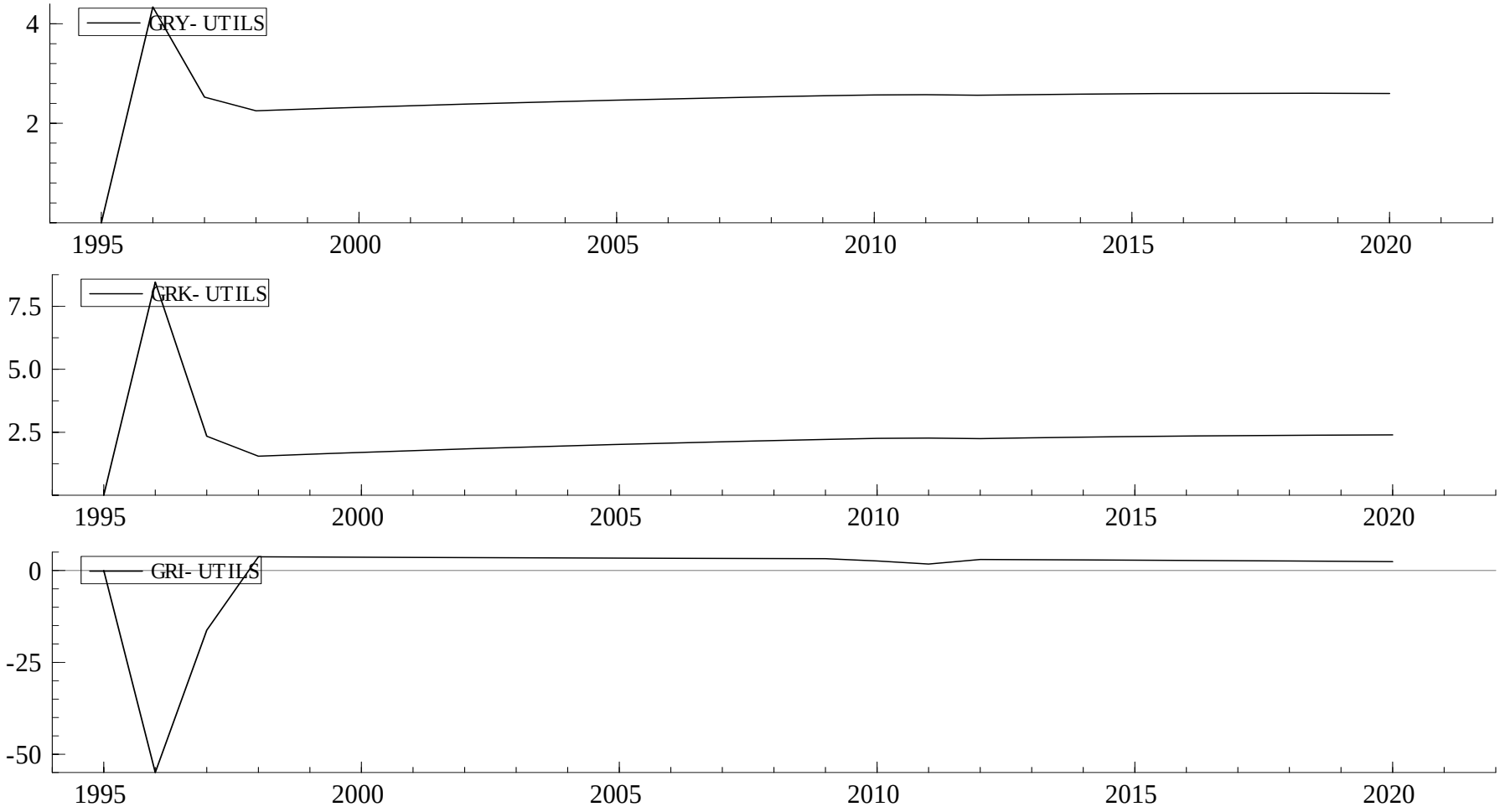
Growth rate of output, investment and capital stock in manufacturing



THE UNIVERSITY OF HULL

Business School

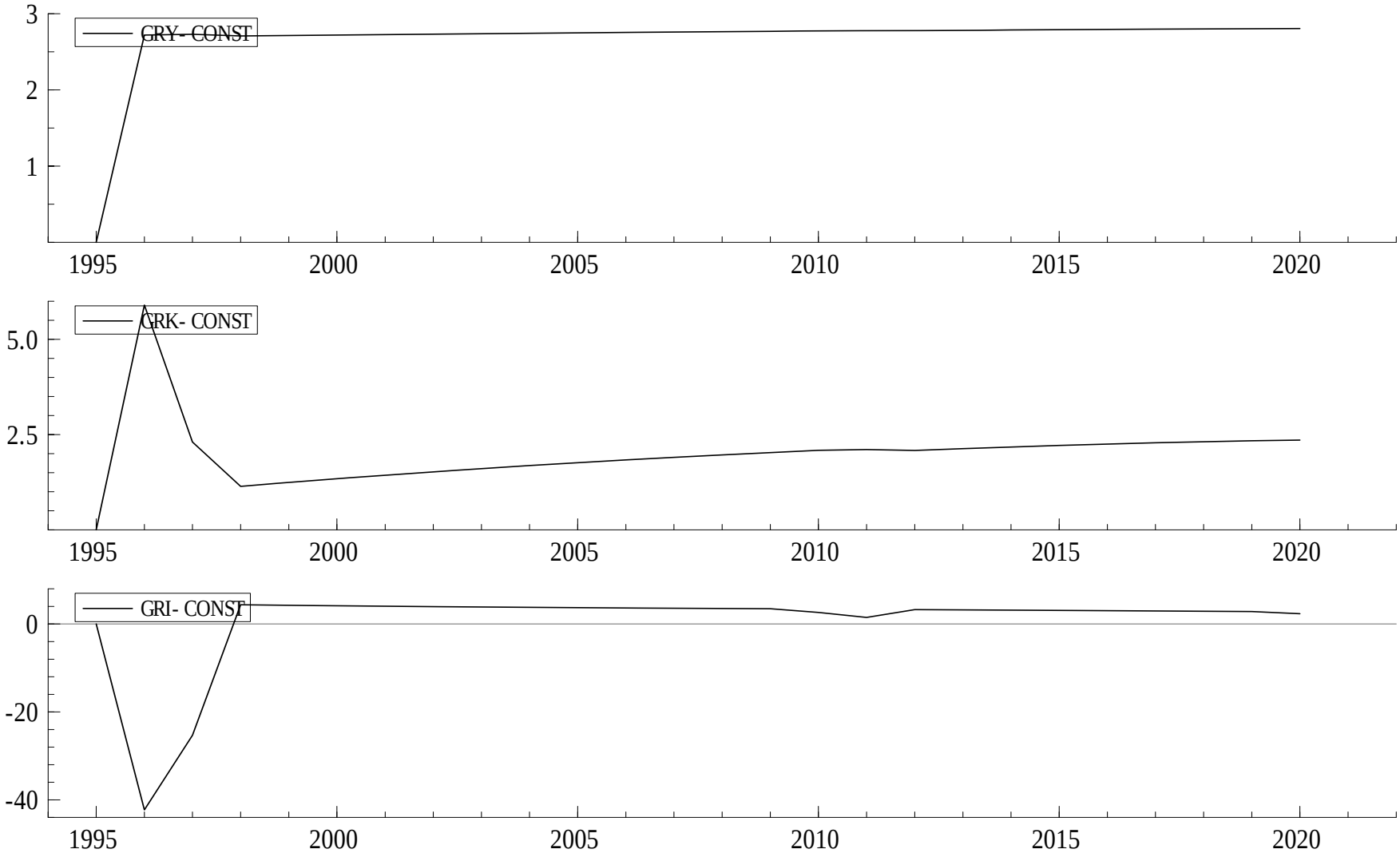
Growth rate of output, investment and capital stock in energy sector



THE UNIVERSITY OF HULL

Business School

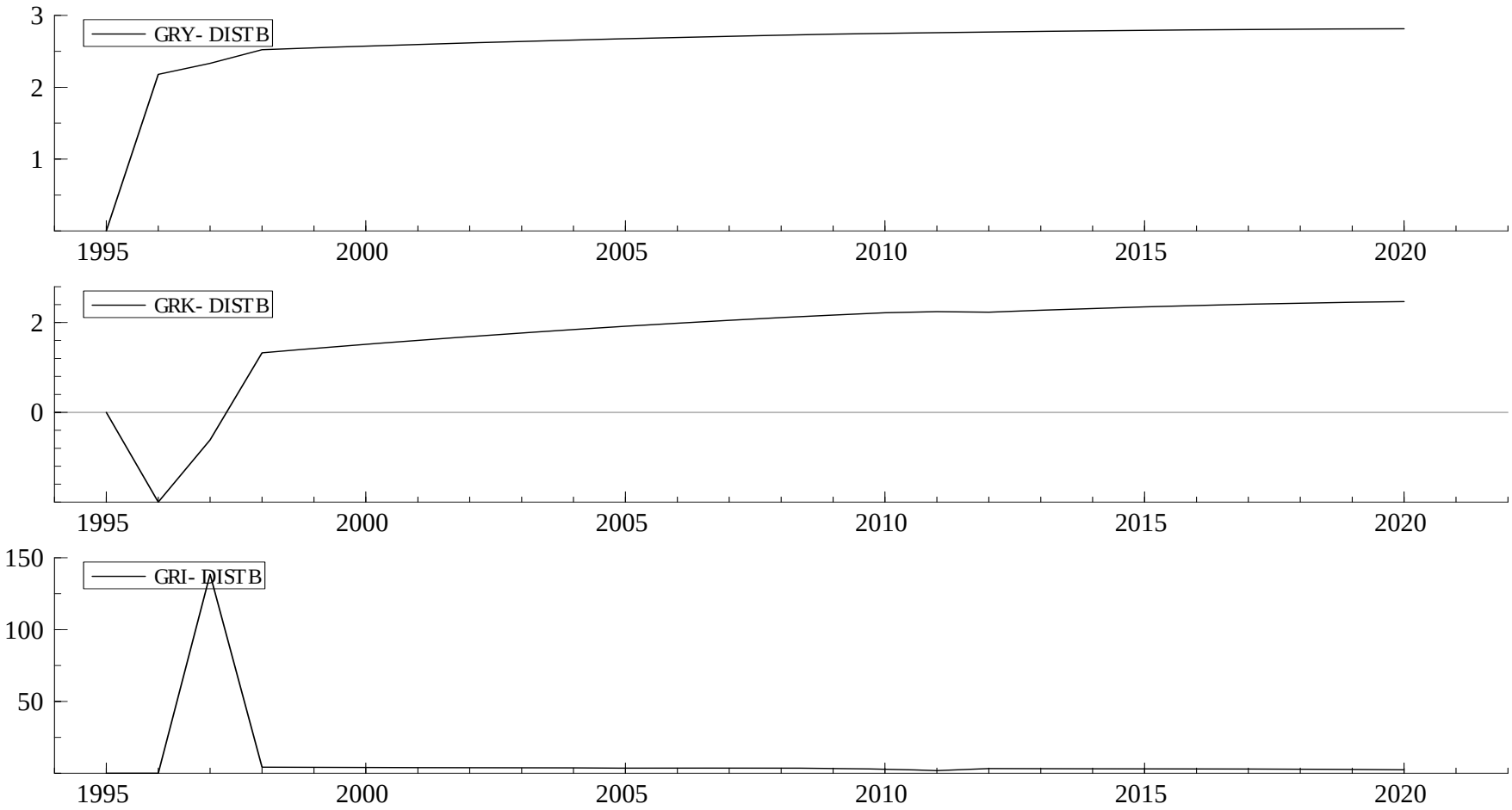
Growth rate of output, investment and capital stock in construction sector



THE UNIVERSITY OF HULL

Business School

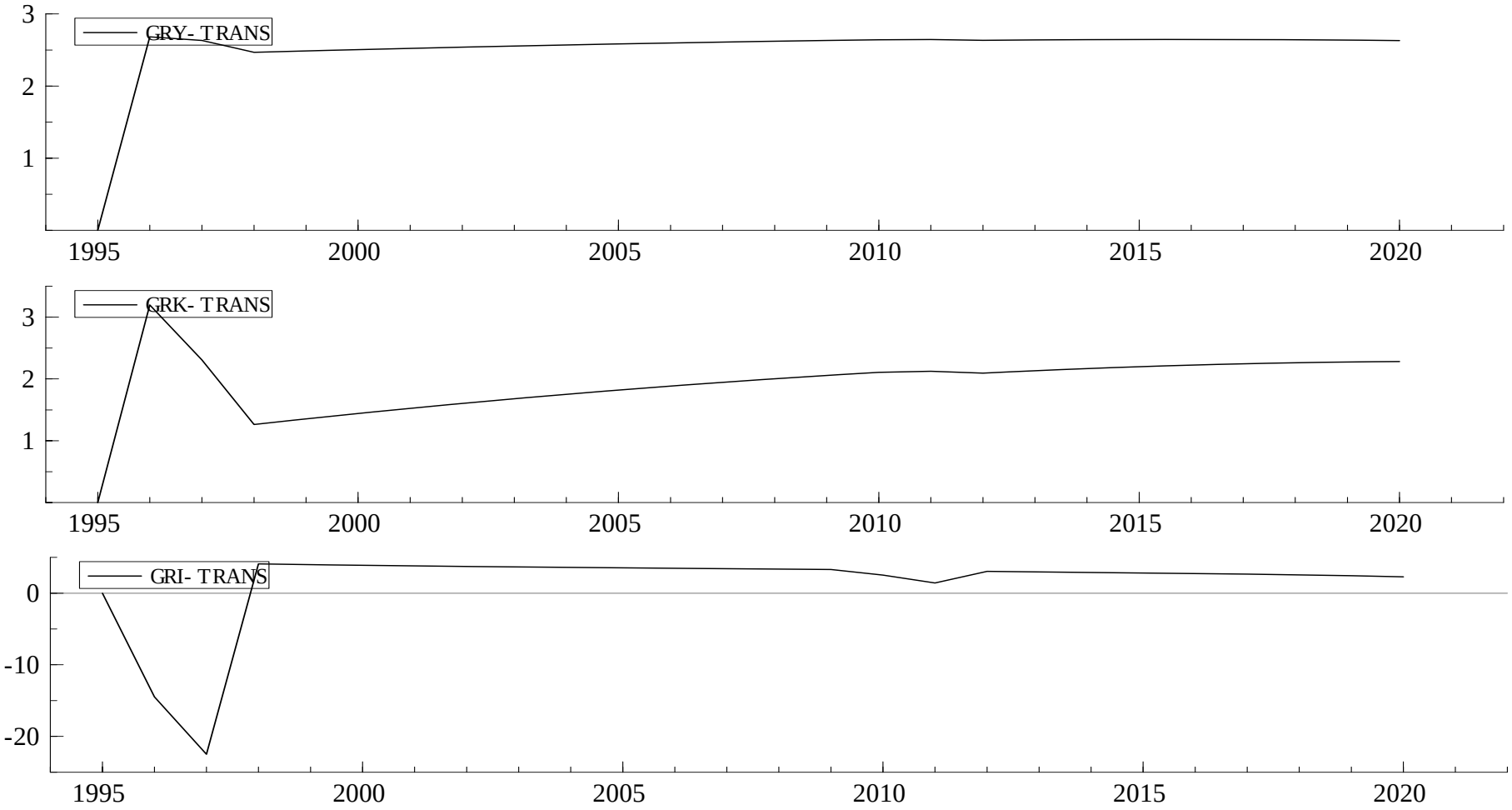
Growth rate of output, investment and capital stock in distribution sector



THE UNIVERSITY OF HULL

Business School

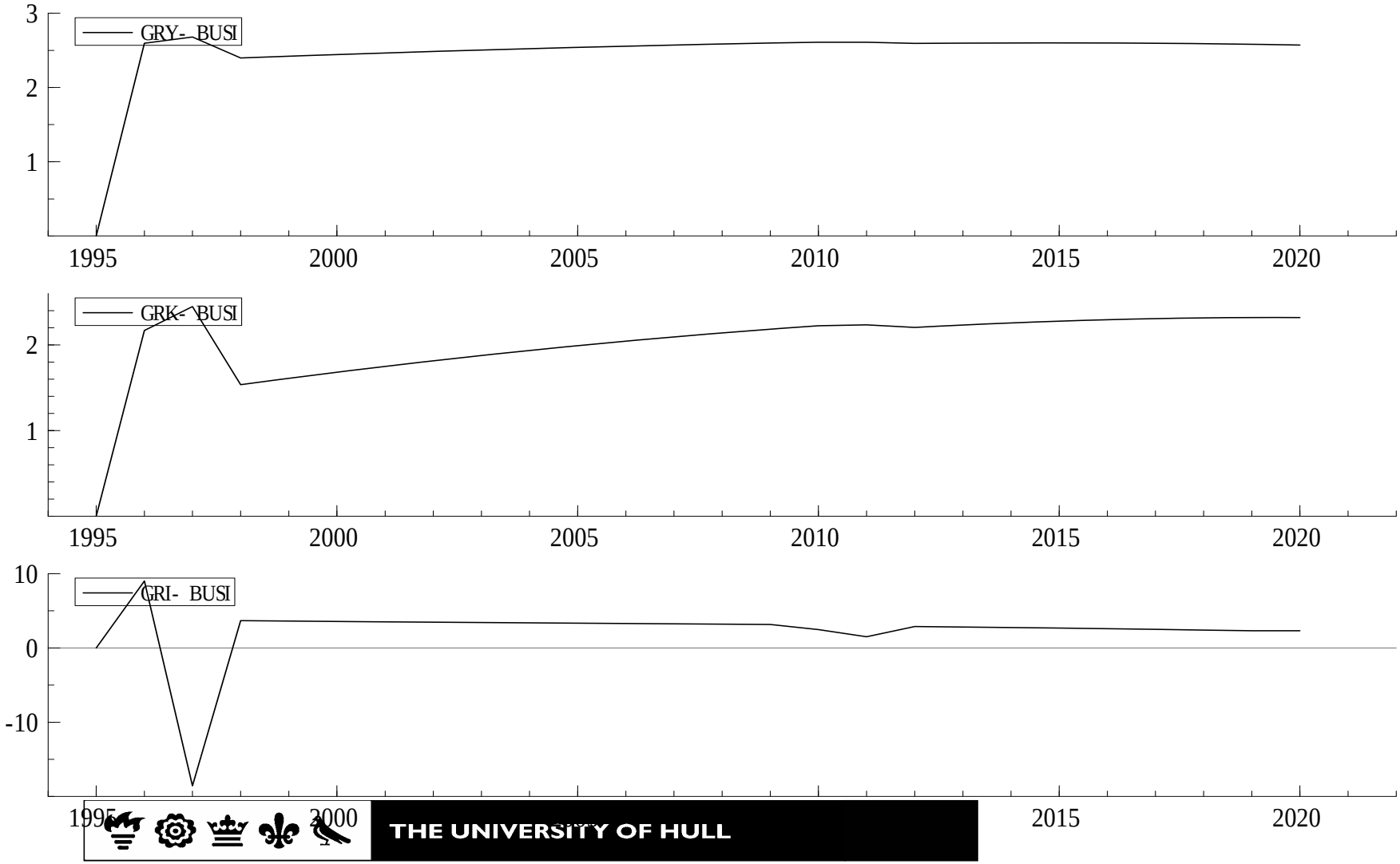
Growth rate of output, investment and capital stock in transport and communication sector



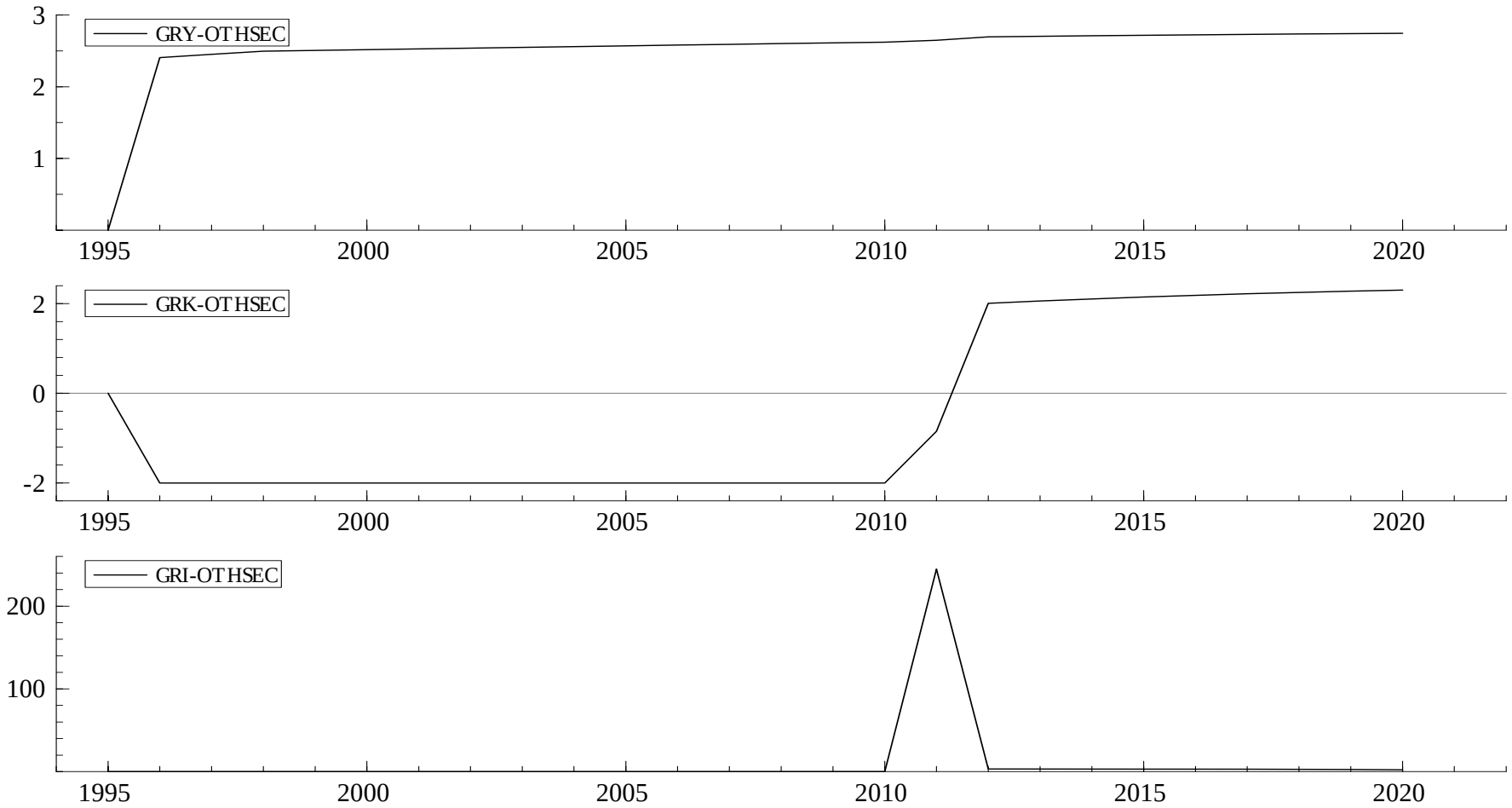
THE UNIVERSITY OF HULL

Business School

Growth rate of output, investment and capital stock in business sector



Growth rate of output, investment and capital stock in other sectors



THE UNIVERSITY OF HULL

Business School