



**HM Revenue  
& Customs**

# **The HMRC Computable General Equilibrium Model**

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# Who are we?

- Jonathan Gillham:

Economist in the Strategy and Personal Taxes Team in KAI: Analysis in HMRC. Responsible for day to day running the model, interpreting the results and contributing to model development. HMRC have funded the development of the CGE model.

- Adam Blake:

Lecturer at Nottingham University Business School. Responsible for model development and technical support.

# Computable General Equilibrium (CGE) Modelling

**Computable:** this is a type of numerical simulation model

- changes are introduced, and the resulting changes in GDP, welfare, output, employment... are calculated.

**General Equilibrium:** supply equals demand in all markets simultaneously

- all intermediate demands are taken into account, and the effects that they have on other sectors are included.
- Differs from traditional “partial equilibrium” analysis where price and quantity adjustments reach equilibrium in an isolated market. Ignoring connections with other markets. Therefore a wider range of effects are modelled.

# Where do CGE Models sit in the Analytical Spectrum?

## Two types of empirical models:

- Macroeconometric models:
  - whole economy
  - interactions of different markets
  - mainly focus on fluctuations of economic aggregates ...
  - ... but not resource allocation and distributional concerns
- Partial equilibrium models:
  - a sector or a market of the economy
  - ignore interdependencies of different sectors

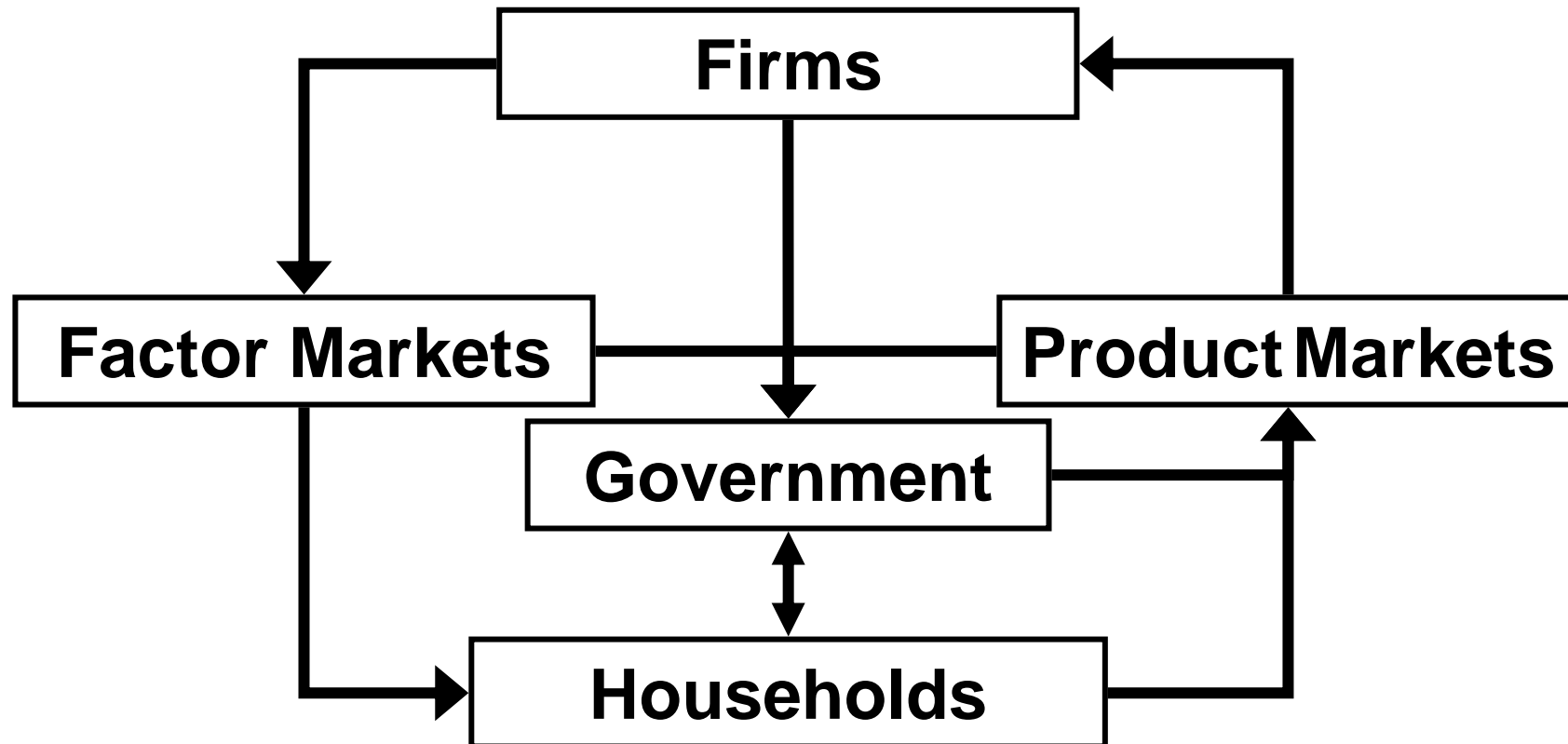
## CGE models:

fill a gap between these two models provide a unique analytical tool in addressing issues of efficiency and welfare based on empirical data, firm theoretical foundation and a whole economy approach.

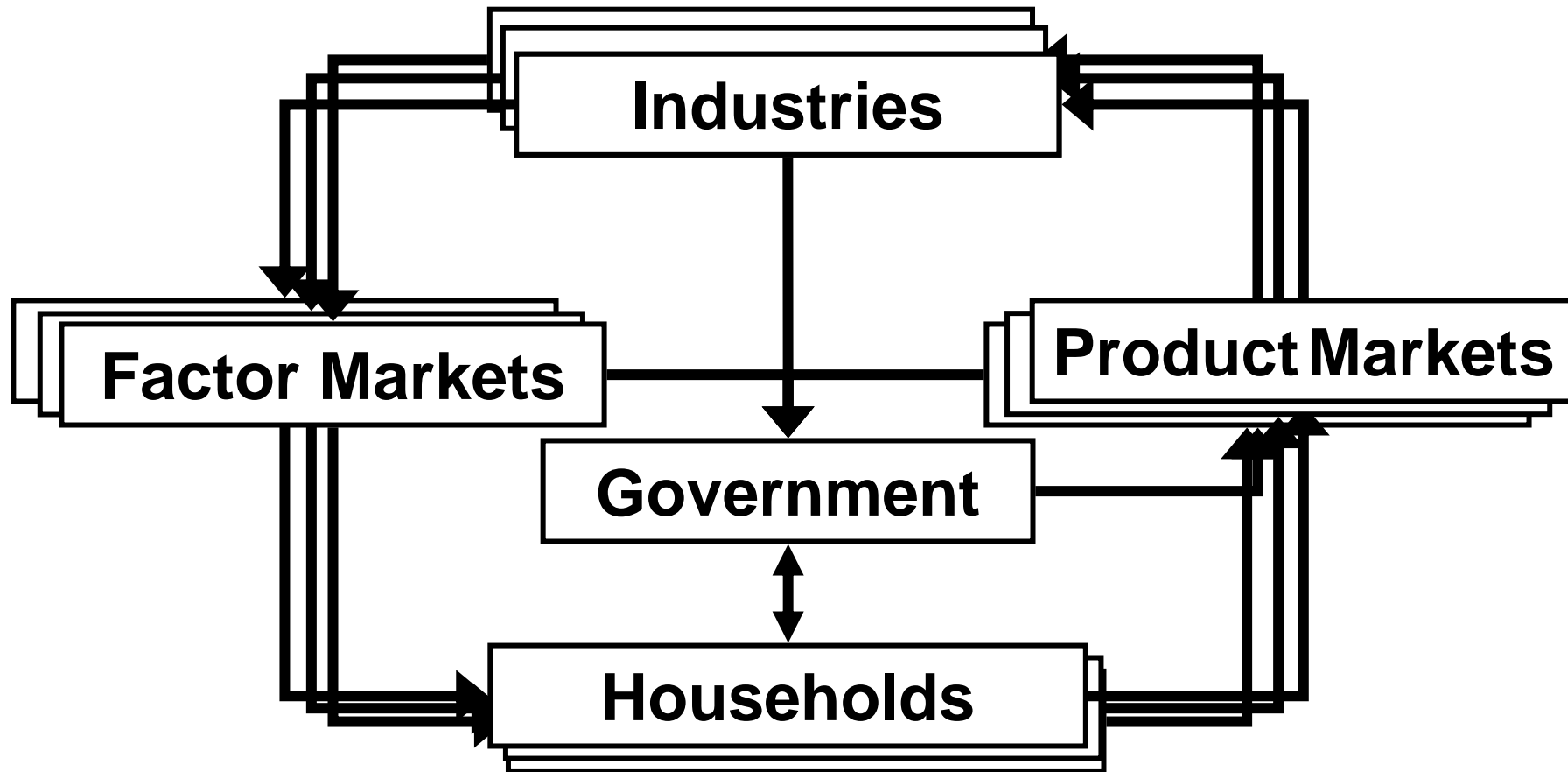
# History of Use

- Amongst academics, CGE models have been used since the early 1970s
  - Effects of customs unions, free trade areas, development policies, trade liberalisation, tax reform, environmental policies, ...
- Internationally used
  - World Bank, WTO, various government agencies particularly in the US and Australia.
  - Some previous use in the UK (Warwick, Nottingham)

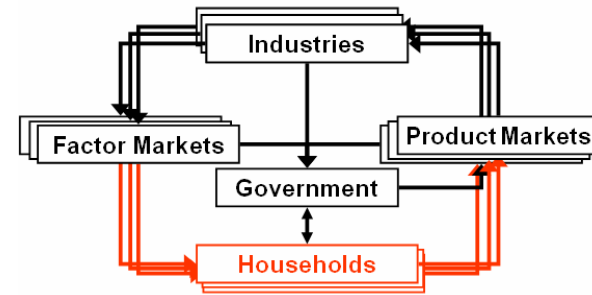
# A simple model of the macroeconomy...



# A simple CGE model...

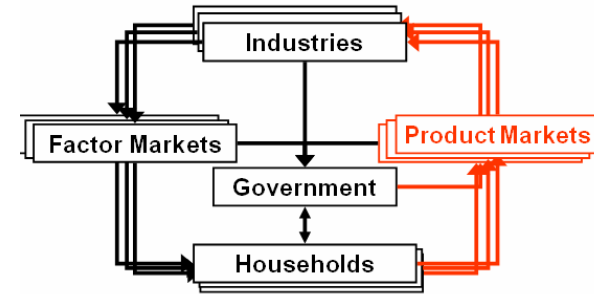


# Household Behaviour



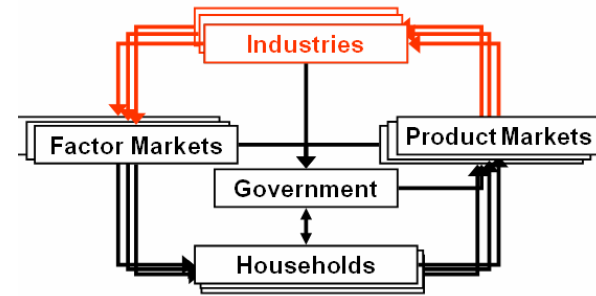
- Rational Expectations
  - Households maximise an objective utility function over the model's time horizon
- Work-leisure choice
- Utility function embodies price and income elasticities (consumers have a minimum requirement in their consumption function).
- Portfolio choice between domestic and foreign assets

# Product Markets



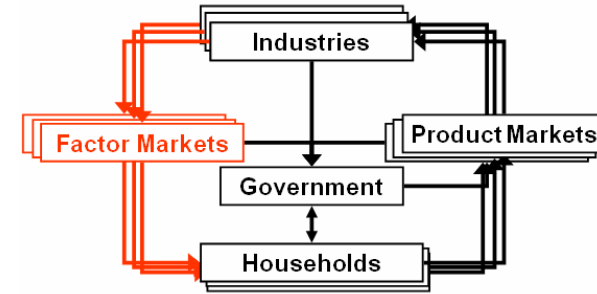
- Exports and imports:
  - Imported products are not exactly the same as domestically produced products - they are qualitatively different
  - and Exported products are also qualitatively different to products sold domestically
  - Current account balance: flexible real exchange rate and fixed foreign savings and transfers

# Firm Behaviour



- Production: nested production structure using CES family of functions.
- Quantity Setting Monopolistic Competition
  - Freedom of entry/exit or restricted entry/exit
  - Different degrees of market concentration in different industries
- Endogenous investment financing decision (debt/equity)

# Factor Markets



- Future earnings are related to the returns from the factors of production.
- Dynamic capital markets:
  - Investment is endogenous; capital accumulation
  - Quadratic adjustment costs
- Dynamic labour markets:
  - Training is endogenous; skill accumulation
  - 'industry specific' and 'firm specific' skills

# Core Model Data

- Ultimately with a CGE model we build an analytically consistent mathematical model of an economy.
- We then collect data on those variables for which data are available; then use the characteristics of the economy at a particular point in time to solve the model numerically.
- The fundamental data premise of a CGE model are 123 sector Supply Use Tables (SUTs).
- The SUTs include an input-output matrix of how goods and services are produced. Therefore a key strength of the CGE model is sectoral analysis.

Combined Use Matrix

| Purchases of Product               | Sales by Industry Group |           |           |           | FSA         | CE | GGFC | GDFCF | Stocks | Exports | Total Final Demand for Products |
|------------------------------------|-------------------------|-----------|-----------|-----------|-------------|----|------|-------|--------|---------|---------------------------------|
|                                    | 1                       | 2         | 3         | 4         |             |    |      |       |        |         |                                 |
| 1                                  | E                       | E         | E         | E         | F           | G  | H    | I     | J      | K       | <b>B1</b>                       |
| 2                                  | E                       | E         | E         | E         | F           | G  | H    | I     | J      | K       | <b>B2</b>                       |
| 3                                  | E                       | E         | E         | E         | F           | G  | H    | I     | J      | K       | <b>B3</b>                       |
| 4                                  | E                       | E         | E         | E         | F           | G  | H    | I     | J      | K       | <b>B4</b>                       |
| Total Intermediate Purchases       |                         |           |           |           |             |    |      |       |        |         | <b>Z</b>                        |
| Taxes Less Subsidies on Production | M                       | M         | M         | M         |             |    |      |       |        |         |                                 |
| Income From Employment             | N                       | N         | N         | N         |             |    |      |       |        |         |                                 |
| Gross Trading Surplus              | O                       | O         | O         | O         | -F          |    |      |       |        |         |                                 |
| <b>Total Inputs</b>                | <b>A1</b>               | <b>A2</b> | <b>A3</b> | <b>A4</b> | <b>Zero</b> |    |      |       |        |         |                                 |

Notes:

FSA Financial Services Adjustment

CE Consumers Expenditure

GGFC General Government Final Consumption

GDFCF Gross Domestic Fixed Capital Formation

We seek to extend the basic structure of the Use Table by linking household income to expenditure.

We seek to decompose Income from Employment and the Gross Trading Surplus

# Structure of Households

**Table 1: Household Mapping and number of Households**

|                   | Retired   | 1 Adult   |         |         | 2 Adults  |         |         | 3+ Adults |         | Total Households |
|-------------------|-----------|-----------|---------|---------|-----------|---------|---------|-----------|---------|------------------|
|                   |           | 0 Kids    | 1 Kid   | 2+ Kids | 0 Kids    | 1 Kid   | 2+ Kids | 0 Kids    | 1+ Kids |                  |
| <b>Quintile 1</b> | 1,491,167 | 862,348   | 259,749 | 359,881 | 533,663   | 208,986 | 539,845 | 493,124   | 280,457 | 5,029,220        |
| <b>Quintile 2</b> | 1,857,485 | 543,695   | 196,045 | 241,450 | 505,892   | 249,800 | 648,203 | 529,272   | 261,533 | 5,033,375        |
| <b>Quintile 3</b> | 1,410,643 | 610,585   | 155,890 | 127,414 | 749,426   | 315,437 | 648,600 | 754,882   | 258,401 | 5,031,278        |
| <b>Quintile 4</b> | 881,144   | 732,380   | 93,016  | 33,916  | 1,220,023 | 403,953 | 617,336 | 837,128   | 216,789 | 5,035,685        |
| <b>Quintile 5</b> | 415,554   | 1,048,604 | 40,105  | 14,868  | 1,881,169 | 433,159 | 448,812 | 632,366   | 120,778 | 5,035,415        |

- There are 45 different types of households in the CGE Model. Nine Different household types with five income quintiles. This gives the potential for a fairly rich distributional analysis.
- For each household type we seek to map income and expenditure consistent with the Use table. This means collating data from numerous survey's.

# Issues Around CGE Modelling

- CGE models are often criticised for their assumptions relating to key elasticity parameters and model properties. We can test these assumptions extensively through Systematic Sensitivity Analysis (SSA).
- We have included a substantial amount of “add-on” features, these can be switched on/off so we can understand their influence on the results.
- CGE models are highly flexible and can be adjusted with relative ease so that they are fit for their analytical purpose.
- As with all models, the strength of a CGE model is predicting the ordering and impact of key economic relationships, not necessarily detailed forecasting.

# What can a CGE Model tell us?

- CGE modelling can provide a unique tool to look at key issues with regard to the economic incidence of tax changes i.e. who bears the burden (consumers, producers, household types etc.)
- It also gives a rich array of sectoral and distributional results. No other class of model can provide these linkages.
- Based on economic theory the model is calibrated so that some agents have alternative speeds of adjustments. This helps us understand potential short-term adjustment effects.
- However, the model only shows deviations from the steady state, it does not assume an endogenous policy response e.g. a change in interest rates
- The CGE model seeks to capture the whole economy, thus meaning that some detailed relationships will be simplified, so CGE modelling is a complement rather than a substitute for other tax policy analysis.