



HM Revenue  
& Customs

# Response to the peer review of HMRC's CGE model

December 2013

## HMRC's response to the peer review of the CGE model

1. HMRC would like to thank Professor Christoph Böhringer and Professor Thomas F. Rutherford for their valuable comments and recommendations made in the peer review of HMRC's CGE model. Böhringer and Rutherford are world-renowned in the CGE field having published many articles in CGE between them. Rutherford is the developer of MPSGE programming language and compiler that we use to run CGE models. We are encouraged that they find that the "basic design of the HMRC model for the UK economy meets at large the key requirements for state-of-the-art applied tax policy analysis."
2. The rest of this document addresses the issues raised under short-term modifications and mid-term extensions. In what follows the comments made by the peer reviewers are shown in italics. All further model development will be based on a careful prioritisation of available resources.

### Short-term extensions

#### Specification of transfers

3. *In the current model formulation transfers between the government and the private agents are expressed through a specific transfer good for which supply and demand arises solely through endowment entries. This can lead to unreliable model results. The point is that if a commodity does not have an inherent value determined through markets, the implicit value of transfers of that commodity is undefined. To fix the problem we suggest denominating transfers in terms of a marketed good such as the composite consumption good or foreign exchange.*
4. **Response:** We agree with the peer reviewers and have asked them to implement the recommendation by denoting government transfers using a composite consumption good. This has improved the accuracy of the results by removing the superfluous supply and demand through endowment entries.

#### Terminal constraints

5. *Dynamic general equilibrium models exhibit a turnpike property. One can exploit this when an infinite horizon equilibrium must be approximated with a finite horizon model. To assure invariance of model results with respect to the time horizon, a set of appropriate terminal conditions must be specified. We recommend the inclusion of post-terminal capital stocks for each sector as endogenous variables. Using state*

*variable targeting for these variables, the growth of investments in the terminal period can be related to the stable long-term growth rate of the economy. These constraints impose balanced growth in the terminal period but do not require that the model achieves steady-state growth. Furthermore, the choice of the time horizon must reflect the stringency of the policy shock under investigation.*

6. **Response:** The peer reviewers have implemented the post-terminal capital stocks for each sector as per the recommendation. In practical terms this means that our results are less sensitive to simulation duration. For all simulations we run the model under the longest time horizon possible to ensure robust results.

### **Baseline calibration**

7. *The model is calibrated to steady-state growth path which seems appropriate for the analysis of fiscal tax reforms given the exogenous growth prescriptions of the dynamic Ramsey framework. A central challenge involved in calibrating a dynamic model centres on the reconciliation of base-year capital earnings, investment, the steady-state interest rate, the exogenous growth rate and the capital depreciation rate. Observed base-year values for capital earnings and investment typically are not consistent with arbitrary values of growth, interest and depreciation rates. Something usually has to be adjusted to match up the dataset with the baseline growth rate. In the current HMRC calibration sector-specific risk premiums are used for this adjustment leading to a wide range of positive and negative mark-ups on the risk-free reference rate of return. We recommend revising the adjustment procedure towards changes in implied base-year capital earnings.*
8. **Response:** We agree that using base-year capital earnings will improve model robustness and solution convergence. The peer reviewers have implemented the required adjustment in the model.

### **Labour-leisure choice**

9. *Labour supply in the standard model can be either treated as fixed or endogenous. In the latter case, labour supply is elastic through demand for leisure which enters intra-period utility of households on a nested CES function over leisure and non-leisure consumption commodities. We recommend calibration of the CES elasticity in line with empirical estimates on the elasticity of labour supply with respect to the real wage.*
10. **Response:** Labour supply elasticity is an important parameter as it can significantly affect the outcome of some simulations. As suggested by the peer reviewers, we carry out sensitivity analyses on the CES elasticity within the range quoted in the

empirical literature. This exercise is particularly important given the high level of disaggregation of households in the model, and empirical evidence on elasticities tends to be at a more aggregate household level.

### Documentation and streamlining of model/data routines

11. *The current model package is poorly documented – both with respect to direct comments and explanations in the programming code as well as with respect to technical documentation for non-programmers. The review suggests that the model and the data underlying its parameterization should be thoroughly documented - via in-line documentation throughout the programming code and via technical reports. Furthermore, there is scope for a more proficient organization of data input routines, model code and results reporting. This is an important pre-requisite for both the internal workforce at HMRC as well as cooperating external consultants to make efficient use of the model package and develop it further according to customers' needs.*
12. **Response:** Since the CGE peer review was tendered, we have made significant progress in documenting the model. We have published a description of the model and we have annotated the model code with in-line descriptions of the variables, parameters and equations.

### Mid-term extensions

13. *There are a couple of mid-term extensions that could substantially enhance the scope of applicability of the HMRC model package. The extensions are listed without prioritization and written pleadings:*

### Refinement of debt-/equity-financing and treatment of risk

14. **Response:** In the model, firms finance investments using debt (new loans) or equity (retained earnings). The current setup works fine and gives sensible results. However, given that the distinction between debt and equity has not been widely implemented within the CGE modelling framework, it is difficult to compare our methodology. The peer reviewers suggest an in-depth examination of the academic literature in order to push the boundaries of CGE research to model the debt-equity bias. We will consider this during future development of the financial sector in the model.

### Calibration of a linear-expenditure system

15. **Response:** We have re-calibrated our linear expenditure system in response to this peer review. The minimum requirement levels in the linear expenditure system are now calibrated to both price and income elasticities of demand for each commodity.

### Refined representation of initial energy taxes and subsidies

16. **Response:** We have an environmental model which captures carbon emissions, environmental taxes, emission trading scheme and a detailed treatment of the energy sectors. In future we will consider combining this model with the tax model that was the subject of this peer review.

### Reduced form implementation of involuntary unemployment (e.g. wage curve)

17. **Response:** Incorporating involuntary unemployment would improve the functionality of the labour market module. We will consider how this might be done in a future model extension.

### Alternative representation of imperfectly competitive market structures

18. **Response:** Imperfect competition could be a valuable add-on especially when estimating the incidence of taxes on prices. We will consider whether we can capture this in a future model extension.

### Overlapping generations (intergenerational burden sharing)

19. **Response:** Our current modelling framework is not able to address intergenerational issues. The introduction of overlapping generations would entail a richer representation of savings, bequests and labour force choices within a life-cycle model of consumption. These models are more complex in nature and to implement such a resource-intensive change would require careful thought.