



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

IMPACT ASSESSMENT
RESEARCH CENTRE
WORKING PAPER SERIES

Paper No: 12 / 2005

How Useful Are Computable General
Equilibrium Models for
Sustainability Impact Assessment

S. Serban Scrieciu¹

ISBN: IARC Administrator, Institute for Development Policy and Management, School
Further of Environment and Development, The University of Manchester, Harold Hankins
details: Building, Precinct Centre, Booth Street West, Manchester M13 9QH, UK.
Published Tel: +44-161 275 2808 Fax: +44-161 275 0423
by: Email: iarc@manchester.ac.uk
Web: <http://www.manchester.ac.uk/sed/idpm/research/iarc>

¹ S. Serban Scrieciu, PhD is a Research Associate with the Institute for Development Policy and Management, School of Environment and Development, The University of Manchester.
Email: serban.scrieciu@manchester.ac.uk.

Abstract

Computable general equilibrium (CGE) modelling represents a powerful tool for hypothesising possible sustainability outcomes that might be triggered with the implementation of policy proposals. Nevertheless, CGE modelling is based on several tight general equilibrium and neoclassical micro-economic theoretical assumptions that make their application to the assessment of all three pillars of sustainability questionable. Although some of these assumptions have been relaxed in recent and more advanced CGE models, further research needs to be undertaken in order to bring model specifications closer to realistic behavioural relationships. CGE models also tend to focus on alternative equilibrium outcomes and rarely deal with the adjustment process or regulation measures needed to realistically bring the economy into the desired new equilibrium stance. Moreover, CGE models inherently face severe rigidities when attempting to deal with environmental and social effects. However, some authors have argued that CGE modelling may provide a suitable backbone for all three dimensions of Sustainability Impact Assessment (SIA). The paper takes a critical stand and supports the view that though CGE models may provide some useful information on individual, particularly economic, impact aspects of policy reforms, it may be inappropriate and even misleading to rely extensively on their use in SIAs.

1. Introduction

The concept and practical implementation of Sustainable Development has become a key issue for policy agendas, research topics and even business plans. The Brundtland Report (or “Our Common Future”) officially initiated the ongoing concern for sustainable development by defining it as a process that “seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future” (Brundtland, 1987). The need to provide a systematic and rigorous analysis of the effects of major policy changes on sustainability outcomes has been increasingly recognised, and has led to the ongoing development of integrated methodological frameworks for assessing the impact of policy on sustainable development.

The Sustainability Impact Assessment (SIA) methodology constitutes a response to this need.² It represents a relatively new conceptual approach for the ex-ante appraisal of the potential impacts of policy reform on sustainable development that has been particularly

² The Sustainability Impact Assessment (SIA) methodology was originally developed at the Institute for Development Policy and Management, University of Manchester at the initiative of the European Commission (Kirkpatrick, Lee and Morrissey, 1999). *Ex-ante* assessment of policies has emerged since the late 1990s, when the European Commission geared its efforts towards incorporating economic, environmental and social concerns into its policy formulation process (EC, 2004).

applied to trade negotiations and trade liberalisation measures.³ SIA includes major improvements from previous traditional policy assessments in the sense that it adopts an integrated approach covering the economic, environmental and social impacts of policy reforms, and in addition to the identification of potential effects, it assesses likely short and long-run trade-offs and the adoption of accompanying measures that allow for both the enhancement of positive effects and the mitigation of negative effects (George and Kirkpatrick, 2004).⁴

SIA does not however recommend a particular set of tools or approaches to assessing potential economic, environmental and social effects. It draws on a wide range of both quantitative and qualitative applications, largely depending on the policy category to be assessed, the level of analysis and the typology of effects. However, recent studies have argued that potential trade-offs between the economic, social and environmental pillars of sustainability may be more adequately addressed through the greater use of numerical modelling techniques, particularly computable general equilibrium models (CGE)⁵ (Böhringer and Löschel, 2004, Böhringer, 2004, Ferguson et al, 2005). These papers generally argue for the incorporation of sustainability indicators into numerical equilibrium modelling frameworks, and implicitly for the intensive use of these techniques to undertake sustainability impact assessments:

“The quantification of tradeoffs requires the use of numerical model techniques. There is simply no other way to think systematically and rigorously about the interaction of the many forces that interact in the economy affecting potential indicators of Sustainable Development” (Böhringer, 2004: 10)

This chapter addresses this particular methodological aspect of Sustainability Impact Assessment and investigates to what extent CGE modelling may be capable or not of

³ SIA studies include assessments undertaken at multi-national and national level, such as those conducted by the European Commission for the appraisal of EU major policy proposals (also known as extended impact assessments, ExIA) (EC, 2005); the evaluation of the impact of greater trade and investment on sustainable development as part of the UK White Paper 2004 on trade and investment (Kirkpatrick, George and Scricciu, 2004); the assessment of national sustainable development strategies in transition economies (Cherp, George and Kirkpatrick, 2004); and the sustainability impact assessment of WTO’s Doha Development Agenda (Lee and Kirkpatrick, 2001, George and Kirkpatrick, 2003).

⁴ A further important feature of the SIA methodology is that it incorporates a consultation process with the active involvement of stakeholders in the assessment process (George and Kirkpatrick, 2004). Hence, the SIA methodology broadly addresses two complementary issues that feed into each other at various stages, namely an economic, environmental, and social assessment undertaken in a clear, scientific and objective manner, and a consultation and dissemination process among stakeholders (European Commission, 2004).

⁵ Computable general equilibrium models (CGEs) are also referred to in the literature as applied general equilibrium models (AGEs). Although the latter would represent a more appropriate name for these models (as their aim is to turn general equilibrium structures “from an abstract representation of an economy into realistic models of actual economies”, Shoven and Whalley, 1984:1007), the former label is employed in this chapter in order to conform to the common practice found in the modelling literature.

adequately addressing the interdisciplinary potential criteria of the SIA process. In other words, it critically evaluates the proposition forwarded in the literature (with an illustration of the Böhringer studies) advocating the use of Computable General Equilibrium models as the main analytical framework for effectively assessing sustainability outcomes of policy interference. An important caveat should be made to this stage, namely that we acknowledge the usefulness of CGE modelling for some dimensions of policy analysis. Nonetheless, the chapter seeks to question the legitimacy of extensively, or even exclusively, relying on such modelling tools for the analysis of the multi-dimensional and interdisciplinary concept of sustainability. It focuses particularly on the weaknesses and shortcomings emerging from the main theoretical assumptions underpinning CGE models.⁶

The chapter is structured into four sections. The following section briefly discusses the concept of computable general equilibrium modelling. Section III evaluates to what extent the literature on CGE modelling has addressed sustainable development issues. Section IV offers a critical appraisal of the appropriateness of using CGE models as a main tool or fundamental analytical framework for an effective SIA. Section V concludes and draws some policy implications.

II. CGE modelling: some conceptual issues

CGE models usually cover economy-wide impacts on resource allocation and incomes (Kousnetzoff and Chauvin, 2004), and in addition, account for inter- and intra-industry foreign trade links. They represent a relatively recent category of modelling methods that convert Walrasian general equilibrium models from an abstract representation of an economy to a realistic representation of actual economies (Shoven and Whalley, 1984).⁷ The theoretical underpinning of CGE models also heavily draws on the neoclassical (micro-) economic theory of the optimisation behaviour of rational economic agents against the background of general equilibrium theoretical structures. Although the computer representation of the economy is complex enough to reflect its essential features, it may still retain the tractability characteristics of their analytical counterparts (Kehoe and Kehoe, 1994). In other words, the CGE methodology allows models of large dimensions to be quantitatively solved whilst retaining the basic general equilibrium structure of their

⁶ However, other downsides of the methods may be further identified if one evaluates in detail the appropriateness of functional forms, closure rules, "dynamic" modelling elements and other aspects related to modelling performance (see, for example, Grassini, 2004, and McKittrick, 1998, for a more in-depth critical evaluation of CGE models).

⁷ The Walrasian general equilibrium theory states that in an economy where consumers are endowed with factors and demand produced goods, and firms demand factors and produce goods with a fixed coefficients production technology (or more generally, a constant returns to scale production function), both output and factor markets clear, whilst perfect competition assures that producer prices equal the costs of production for every operating activity.

theoretical counterparts (Glebe, 2003). This is because CGE models have emerged as the result of combined efforts of theorists that laid the foundations of general equilibrium theory, applied economists that looked at the real economy using the theoretical foundations, and mathematicians that have developed tools to bring about the feasibility of numerical computations (Grassini, 2004)

A more compact definition may thus present an CGE model as an analytical deterministic integrated system of non-linear equations derived from the economic theory of optimising behaviour of rational economic agents that describes the simultaneous linkages between markets, institutions and factor resources that renders an all-markets clearing equilibrium numerical solution. It could be compared to a scientific laboratory experiment where the modelled economy constitutes the subject of the experiment, the assumptions made are the necessary conditions for the experiment to work, and the exogenous policy changes are the shocks that are administered to the subject in order to investigate their potential effect. In other words, the aim of CGE modelling is "... to evaluate policy options by specifying production and demand parameters and incorporating data reflective of real economies" (Shoven and Whalley, 1984: 1007).

Numerical CGE models are based on classical analytical equilibrium models (formalised by Arrow and Debreu in the 1950s), according to which a unique general equilibrium solution in competitive markets may arise if three equilibrium conditions are simultaneously satisfied (Mathiesen, 1985, Paltsev, 2004): the "zero profit condition" requiring that any activity that is functioning and operating must earn zero profit; the "market clearance condition" requiring that supply and demand for any good and factor of production must balance; and the "income balance condition" requiring that for each economic agent the value of income must equal the value of factor endowments. However, CGE models represent an extension to classical equilibrium analytical models in the sense that they are mostly policy driven and aim to provide numerical solutions to large multi-sectoral models.⁸ Their main task is to simultaneously find equilibrium prices, quantities, and incomes of an economy where all economic flows are accounted for. In other words, they ensure that there is a "sink" for every "source" (Paltsev, 2004). Furthermore, they are capable of illustrating the respective economic flows in much more detail and complexity than analytical models, which can only afford to work in small dimensions.⁹

⁸ General equilibrium problems have been approached in the last three decades more from a computational and practical perspective due to the pioneering work undertaken in the 1950s, 1960s and 1970s notably by James Meade, Harry G. Johnson, Arnold Harberger, H. Scarf, John Shoven and John Whalley.

⁹ Because CGE models usually work at a level of detail halfway between micro and macro variables, some authors have labelled their level of detail as being "meso", namely the level at which policy makers are interested in (Grassini, 2004).

Computable general equilibrium modelling hence represents a flexible analytical and simulation device for distinguishing between the multiple effects that might be brought about by the implementation of a set of combined policy issues (FAO, 2003). It also has the main advantage of addressing the workings of an economy in an integrated manner and considering the complex inter-linkages, feedback and spill-over effects between all the sectors and economic agents operating in the modelled economy.

III. CGE modelling and Sustainability Impact Assessment

The modelling literature dealing simultaneously with interactions between all three - economic, social and environmental - components of sustainable development is extremely sparse. This is because both the SIA concept and CGE economic modelling techniques to incorporate sustainability issues have only recently emerged. However, there are several studies that model the impact of policy changes on individual relationships/aspects of the sustainability process, for example issues pertaining to economic and environmental development or between economic and social aspects.

On the one hand, an increasing number of studies address the relationship between greater trade liberalisation and environmental performance or environmental policies. These are performed at various aggregation levels, from a global perspective (Perroni and Wiggle, 1994, Cole and Rayner, 2000, Copeland and Taylor, 2004, and Nijkamp, Wang and Kremers, 2005), on a regional scale (Brown, Deardoff and Stern, 1992 and Anderson, 2001, for NAFTA, Löschel and Mraz, 2001, and Zhu and Ierland, 2001, for an extended EU), or at a country level (Anderson and Strutt, 1998, for Indonesia, Townsend and Ratnayake, 2000, for New Zealand, Dean, 2000, for China). The modelling approach generally attaches an environmental module to production or consumption functions often under the form of technical coefficients of emissions (for example, Nijkamp, Wang and Kremers, 2005, add an explicit capital-energy composite input into the production structure).

On the other hand, a growing body of CGE modelling literature investigates the impact of policy proposals or policy changes not only on economic growth but also on social welfare, poverty and equity. For example, Mbabazi (2002) analyses short-run welfare impacts of trade liberalisation in Uganda, Humphreys (2000) evaluates within an CGE modelling framework, poverty and distributional impacts of trade liberalisation in South Africa, and Coady and Harris (2004) adopt an augmented CGE approach¹⁰ that addresses the welfare impact of cash transfers targeted at rural areas in Mexico.

¹⁰ These represent latest developments in CGE modelling techniques that attempt to link a computable general equilibrium model with a representative household module, allowing the researcher to evaluate welfare and poverty impacts consistent with the macroeconomic policies captured in the general equilibrium model (World Bank, 2003).

This chapter does not go into more detail pertaining to the above-mentioned literature because the present analysis deals with issues of measuring the impacts of policy initiatives on the three pillars of sustainable development from an integrative and not separated standpoint. The chapter hence focuses on studies that have attempted to use CGE modelling as an exclusive tool in providing an integrative assessment of the sustainability dimension. More precisely, the chapter offers a critical discussion of the approach undertaken in Böhringer and Löschel (2004) and further pursued in Böhringer (2004), which are amongst the few studies that argue for the particular suitability of computable general equilibrium models for measuring all three pillars of sustainable development.¹¹

Böhringer and Löschel (2004) presents the case for the use of Computable General Equilibrium modelling as a flexible backbone tool for quantifying the impacts of policy changes or proposals on the three pillars (economic, environment and social) of sustainable development. The authors assert that CGE modelling may represent a good fit of the requirements for a comprehensive Sustainability Impact Assessment (SIA):¹²

“[...] computable general equilibrium models can incorporate several key sustainability (meta-) indicators in a single micro-consistent framework, thereby allowing for a systematic quantitative trade-off analysis between environmental quality, economic performance and income distribution” (Böhringer and Löschel, 2004: 3)

The authors start their arguments by displaying two lists of policy-relevant systems of sustainable indicators that may be partially addressed within an CGE modelling framework. These refer to the list of *Indicators of Sustainable Development* developed by the United Nations Commission on Sustainable Development (CSD) and a list compiled by the European Commission with the aim of evaluating the progress of the EU towards sustainable development. Both sets of indicators of sustainable development are constructed with the scope of being used at a national level.¹³ A large number of these sustainability indicators can be included within a CGE modelling framework according to Böhringer and Löschel

¹¹ Although, Ferguson et al (2005) mention in their title “incorporating sustainability indicators into a Computable General Equilibrium model”, their study addresses only the economic-environment relationship, and within this relationship only environmental aspects pertaining to output emissions and global warming.

¹² In this regard, Böhringer and Löschel (2004) and Böhringer (2004) acknowledge that their exclusive focus on quantitative CGE-based analysis should not exaggerate the role numerical approaches may play in SIA.

¹³ The list compiled by the United Nations CSD contains a set of 58 “core indicators” that are grouped within 15 themes and 38 sub-themes, covering the three main pillars of sustainable development (economic, social and environmental) plus an institutional component reflecting the framework and capacity of each country to implement corresponding sustainability measures. The list forwarded by the European Commission encompasses only fourteen structural indicators that facilitate the process of evaluating the progress made by EU member states towards sustainable development.

(2004). This would provide a quantitative approach to SIA and lead to better-informed policy decision-making (Böhringer, 2004).

The authors develop a standard (“core”) CGE model to which they propose several extensions that would increase the policy relevance and would cover a wider range of indicators for SIA. The generic model represents a standard comparative-static multi-sector and multi-region model of trade and environmental or energy policies that employs three primary factors of production (labour, capital and resource of fossil fuels) and non-energy intermediate inputs. The assumptions of no change in the employment of resources, constant returns to scale and perfect competition are generally associated with standard CGE models.¹⁴ However, the Böhringer and Löschel (2004) core model has limited application for SIA purposes in the sense that besides the fact that it addresses only the economic and environmental components,¹⁵ when it comes to the latter it provides only a quantitative assessment in terms of emissions from fossil fuel combustion (namely, CO₂) and may simulate only a very narrow spectrum of environmental policy responses, such as a carbon tax.

A series of extensions are also discussed in Böhringer and Löschel (2004) that may develop the core model towards a better assessment of potential interactions and trade-offs between various sustainability indicators. These refer to the inclusion of non-CO₂ greenhouse gases, accounting for market distortions such as taxes or subsidies, involuntary unemployment and imperfect competition, adding dynamic specifications and endogenous technological change. The disaggregation of the representative agent into heterogeneous households would allow for the analysis of equity issues, as well as linking models to ensure a more comprehensive coverage of SIA requirements. The authors merely present how each of the proposed extensions may be capable of widening the policy relevance for SIA, but do not provide greater detail on their practical implementation and incorporation into the standard CGE model.

A more detailed explanation of possible CGE methodological extensions and their relevance for SIA is put forward in Böhringer (2004). The author acknowledges that one of the main weaknesses of CGE numerical modelling is that it is very difficult to distinguish between the

¹⁴ In a standard model output is derived from a Leontief combination (namely zero elasticity of substitution) of intermediate inputs and aggregate value added, the latter consisting of nested constant elasticity of substitution cost functions. The Armington assumption is also employed to differentiate domestically produced goods from imported commodities.

¹⁵ The core model includes in its framework only six (GDP per capita, balance of trade in goods and services, intensity of material use, annual energy consumption per capita, intensity of energy use and emission of greenhouse gases) out of fifty-eight indicators on the United Nations CSD list and four (GDP per capita, labour productivity, greenhouse gas emissions and energy intensity of the economy) out of the fourteen structural indicators on the European Commission's list.

numerous general equilibrium effects that are at work and that drive the simulation results, i.e. the black box critique.¹⁶ He then presents in more depth two alternative decomposition techniques that would identify the economic channels through which international trade may transmit policy impacts. Further extensions to the core CGE model are represented in terms of specifying and solving optimal policy problems, or undertaking systematic sensitivity analysis for key elasticities. Nonetheless, although the proposed extensions to the core model are essential for a rigorous and robust CGE analysis, they once again do not particularly address sustainability issues. This is because, despite the fact that such proposals to model development are extremely welcome in the modelling literature, they tend to address CGE modelling limitations in general, and do not necessarily provide satisfactory answers to a range of questions particularly pertaining to sustainable development. In other words, the major assumptions that underpin CGE models and their associated limitations raise the question of how useful are these models in providing an effective and reliable assessment of the sustainability impacts of policy changes.

IV. Limitations and drawbacks of CGE modelling for an effective SIA

At first glance, CGE modelling, such as that suggested in the Böhringer and Löschel (2004) and Böhringer (2004) studies, appears to provide the much-needed single consistent framework necessary to quantitatively perform Sustainability Impact Assessments. Nonetheless, when one looks in detail into the workings and underpinnings of computable general equilibrium modelling, one may start to question their ability to deliver plausible assessments of all major aspects linked to the concept of sustainable development.

The first argument pertains to the capacity of quantitative methods in general (and CGE models as a sub-category of these) relative to qualitative approaches in providing a meaningful assessment of sustainability impacts. Although the need to deliver robust and rigorous quantitative SIAs is widely acknowledged, at the same time it is also increasingly acknowledged that many environmental, social and even economic aspects of sustainable development are very difficult to estimate quantitatively (and in some cases, it may not even be desirable).¹⁷ For example, in a multitude of cases the natural capital may have an intrinsic value (not quantifiable in monetary terms) and integrating it within a pricing system based on individual preferences may actually be in conflict with ecological concerns.¹⁸ The difficulty of mathematically formulating and quantifying interactions between economic activities and

¹⁶ The sheer size of CGE models and the difficulty in pinpointing the precise source of a particular result often render these as "black boxes".

¹⁷ However, a more in-depth discussion of the pros and cons of quantitative versus qualitative analysis for sustainability impact assessment is not pursued here.

¹⁸ This view corresponds in fact to the "strong sustainability" approach to sustainable development that argues that the full contribution of component species and processes to life-support capacity is not fully measurable in (economic) value terms at all (Turner, 2002).

the environment become more pronounced for example in the case of agriculture, which plays a multifunctional role and provides, in addition to corresponding private commodities, a series of rural amenities and public goods. Besides the fact that major aspects of the agriculture-environment nexus are not suited for modelling (for example, biodiversity and landscape), those elements of the relationship that may be adequate for modelling continue to be the focus of intense discussions amongst modellers.¹⁹

This leads us to the second argument pertaining to the theory underpinning this type of quantitative approach to evaluation. The entire CGE theoretical framework heavily draws on a combination of general equilibrium theory, neo-classical micro-economic optimisation behaviour of rational economic agents, and some macro-economic elements that attempt to explain economic, and recently, also social and environmental phenomena. In other words, to many economists, the neoclassical approach that extends well-known established liberal concepts, such as supply and demand forces, market equilibrium, profit maximisation, utility maximisation, prices, and monetary valuation to address ecological challenges represents a viable solution in tackling environmental problems. Nevertheless, as Söderbaum (2000) also argues, this encompasses a mechanistic, monetary reductionist approach that places a strong emphasis on the market as the solution to all kind of problems (including environmental and social issues) and fails to appropriately account for the institutional arrangements, ethical issues and the developmental needs of a society within an interdisciplinary, pluralistic, holistic, and dynamic approach. When economic and environmental linkages are assessed within an CGE modelling framework, their complexity tends to be narrowed down for example to the attachment of an environmental module to production or consumption functions often under the form of technical coefficients of emissions (for example the insertion of energy inputs as a primary factor of production in the above Böhringer 2004 study).

Conventional neoclassical theory also assumes that individual behaviour reflects the rational pursuit of self-interest, and consequently, the optimal policy is one that best allows individuals to maximise their personal utility and meet their preferences. However, individual preferences or personal welfare concerns play only a limited role in human behaviour, as persons generally base their choices on a much more complex set of values. For instance, they may display altruistic or sympathetic preferences or may have goals that transcend maximising utility objectives, such as moral values or socially valuable choices.²⁰ The theory

¹⁹ However, in the last few years there tends to be a convergence in the CGE modelling approach for example in response to EU's future shift towards a multifunctional agriculture, namely as a joint production of a pure public good (induced by the government through decoupled direct payments) and an agricultural private good (Cretegny, 2002). The author argues for the importance in considering the multifunctionality of agriculture when analysing the policy impacts on consumer welfare, as it might lead to even opposite conclusions if it is ignored.

²⁰ These are labelled by Amartya Sen as meta-preferences or second-order preferences, as opposed to first-order preferences derived from the standard "rational" economic behaviour.

of optimisation behaviour represents a very specific view of human beings, society and nature. Other theoretical perspectives in both economics and other social and physical sciences, hence, tend to be marginalised or even excluded. Furthermore, neoclassical economists tend to over-emphasise people's autonomy and self-interest, and downplay the influence of others on individual preferences and decision-making, thus ignoring the social networks, interactions and context within which people are generally embedded (Surowiecki, 2005). This raises important questions related to the effectiveness of CGE models based on neoclassical theoretical underpinnings to investigate those social impacts that are significantly determined by social interactions and processes (e.g. education, empowerment, health, intra-household income distribution). In other words, following the path of objectivity (namely a mechanistic observation of regularities) and value neutrality, neoclassical economists claim to provide "optimal solutions" from a societal point of view to environmental and development problems. But, in relation to these latter problems there is no value-free science, as environmental and development issues go much further beyond the limited monistic view of a single discipline (Söderbaum, 2000).

A further critical issue relating to the theory underlining CGE models is the general equilibrium (GE) and the CGE methodology *per se*. Classical GE assumptions include for example perfect competition, full employment of resources and perfectly mobile factors of production. In addition, the general equilibrium theory behind CGE models assumes that there is complete information about all prices now and in the future, and that economic agents implicitly have unlimited computational abilities. Although most of these assumptions have been relaxed in recent and more advanced CGE models, further research needs to be undertaken in order to bring model specifications closer to realistic behavioural relationships, for example, those characterising transitional or developing economies. Moreover, market clearing conditions and the GE rule that every source needs to find a sink (a factor can not be employed in two different places, households cannot spend more than they earn, the society is a waste-free economy) represents a relatively strong reductionist view on the workings of the real economy. In other words, the CGE model builder tends to be satisfied with the choice of some specific functional forms and closure rules, and modifies the available representation of the real world instead of rejecting the model (Grassini, 2004).²¹

General equilibrium modelling often produces a static equilibrium, whereas an open society is grounded in instability and subject to dynamic disequilibrium forces (Soros, 2003). In other words, a steady-state equilibrium is in fact never reached by any economy and the society will always find itself in a never-ending process of change and disequilibrium. The general equilibrium assumption on which CGE models lay their foundations hence suddenly seems

²¹ CGE modelling studies have been criticised for their recourse to models characterised by internally inconsistent assumptions, and their choice of model structure, parameter values and functional forms that best serve their purpose (Panagariya and Duttagupta, 2001).

very unstable, as there is no theory to explain what may happen out of equilibrium and there is no reason to believe that equilibrium is achieved in the real world (Grassini, 2004). The assumption of a steady-state equilibrium becomes even more uncertain in the case of developing or transition economies that continue to undergo rapid and substantial changes (the so-called “transition” handicap outlined in Piazzolo, 2001). Furthermore, though more recent developments in CGE modelling allow for the insertion of “dynamic” elements, these are limited in scope and provide an unsatisfactory description of dynamism within an economy.²² For instance, CGE models may account for capital accumulation effects but remain silent with respect to regulatory and institutional changes that an economy may need to undergo in order to be on the modelled or “desired” adjustment path. In other words, CGE models fail to adequately explain adjustment paths and what may happen during disequilibrium.

Other disadvantages associated with the workings of CGE modelling include: the use of very complicated models and the simultaneous running of several policy scenarios that makes it difficult to identify the triggering factors and mechanisms leading to final outcomes; the borrowing of parameter estimates from other sources and hence difficult to validate in the traditional sense;²³ and a limited macro side that is based upon the money neutrality assumption and hence fails to address monetary policies and the role of nominal variables (inflation, interest rates) in influencing economic outcomes.²⁴

Finally, the nature of CGE modelling and the underlying assumptions that it employs pose the risk of generalising and homogenising completely different economies and societies, thus failing to account for key country- and context-specific differences. For instance, with regard to the economic background of a nation, CGE modelling is weak in dealing with structural details and often starts from the assumption that economic agents are fully capable of responding to the incentives provided under the new policy change and hence act accordingly. Nonetheless, there may be a multitude of structural barriers and institutional impediments that constrain supply responsiveness, particularly in countries that continue to face important market dysfunctions. With regard to the social dimension of sustainable development, CGE models reduce it to equity concerns without consideration for other major

²² On the consumption side, dynamics generally relate to the representation of the savings behaviour of households, whereas on the production side, dynamics refer to the description of the investment behaviour of firms (Böhringer, 2004).

²³ In other words, various parameters are derived from mathematical manipulation (calibration) and are not estimated from statistical fittings of empirical data (econometric critique).

²⁴ The entire CGE modelling framework relies on the classical dichotomy between real and nominal variables or the money neutrality assumption: an increase in prices results in a proportionate increase in money profits with no effect on real activity, demand or any real variables. In other words, the zero homogeneity of demand functions coupled with the linear homogeneity of profits in prices implies that only relative prices affect consumer and producer behaviour, and that the absolute level of prices has no effect on equilibrium outcome (Shoven and Whalley, 1984).

social issues such as education, health or justice (as shown in the Böhringer 2004 example above). Moreover, when it comes to assessing distributional impacts, general equilibrium modelling is relatively weak in spelling out micro-macro links and predicting equity effects across various groups of households. This is largely attributed to the economy-wide type of analysis that CGE modelling undertakes and its tendency to work at high levels of aggregation.

Nonetheless, the insertion of household economic models within a general equilibrium framework (often referred to as “augmented” CGE models) may provide valuable insights on micro-macro links. Complementing general equilibrium work with detailed household modules, though still in its emerging phase, may thus provide more relevant extensions to CGE models for SIA than those proposed, for example, in the Böhringer studies. However, the use of other modelling techniques should be considered in conjunction with CGE modelling tools, and the latter should not be seen as holding supremacy over other alternative quantitative methods of assessment.

V. Conclusions

The chapter critically discussed the appropriateness and selective focus on computable general equilibrium models to effectively provide consistent insights into the overall sustainability impact assessment of policy proposals. The CGE numerical approach may provide a systematic and rigorous quantification of certain potential trade-offs and interactions operating in an economy. Nonetheless, though CGE models may render useful information on some individual aspects of policy appraisal, they are unlikely to perform well when it comes to integrated sustainability impact assessment. Largely because of the tight and unrealistic assumptions underlining general equilibrium theory, and the inherent nature of CGE models that allows only for a limited view on sustainable development, the use of the approach as a main tool for assessing sustainability outcomes may result in inappropriate or even misleading results and policy suggestions. Policy action based on CGE model-driven recommendations may result, in cases where the CGE theoretical assumptions prove wrong or inappropriate, in worse outcomes relative to the case of policy inaction and the absence of CGE analysis to influence decision-making.

Using CGE modelling as a backbone for SIA may lead to the domination of an exclusively quantitative technique that heavily draws on a rather narrow view of economic realities, human behaviour and the interactions between economic, social and environmental dimensions of development. This may seriously infringe upon the basic values promoted by the SIA methodology, namely heterogeneity and the reliance of assessment work on both quantitative and qualitative approaches. It is important hence to understand the weaknesses of evaluating indicators of sustainability in CGE models. In other words, whilst acknowledging

the strengths, advantages and potential of employing general equilibrium modelling techniques in evaluating certain aspects of sustainability, a certain degree of variety and “competing” assessment tools would be essential in rendering useful and integrated SIAs. CGE models may be useful in their context for which they have been initially developed (e.g. the impact of trade or fiscal policy on factor allocation and sectoral outputs), but the range of questions pertaining to sustainable development that they can answer is rather limited.

References

- Anderson, S. (2001) *Seven Years Under NAFTA*, Institute for Policy Studies, Washington DC;
- Anderson, K. and A. Strutt (1998) “Will trade liberalisation harm the environment? The case of Indonesia 2020”, CEPR discussion paper no.1933, Centre for Economic Policy Research (CEPR), London;
- Böhringer, C. (2004) “Sustainability Impact Assessment: the Use of Computable General Equilibrium Models”, *Économie Internationale* no.99, 3^e trimestre, pp: 9-26;
- Böhringer, C. and A. Löschel (2004) “Measuring Sustainable Development: The Use of Computable General Equilibrium Models”, ZEW Discussion Paper no.04-14, Centre for European Economic Research (ZEW), Mannheim;
- Brown, D., Deardoff, A. and R. Stern (1992) “A North-American Free Trade Agreement: Analytical Issues and a Computational Assessment”, *World Economy* 15(1): 11-29;
- Bruntland, G. (1987) *Our Common Future: The World Commission on Environment and Development*, OUP;
- Cherp, A., George, C. and C. Kirkpatrick (2004) “A methodology for assessing national sustainable development strategies”, *Environment and Planning C: Government and Policy*, vol. 22, pp.913-926;
- Coady, D. and R. Harris (2004) “Evaluating targeted cash transfer programs: a general equilibrium framework with an application to Mexico”, IFPRI research report 137, International Food Policy Research Institute, Washington DC;
- Cole, M. and A. Rayner, (2000) “The Uruguay Round and Air Pollution: Estimating the Composition, Scale and Technique Effects of Trade Liberalisation”, *Journal of International Trade and Economic Development* 9(3) pp.339-354;
- Copeland, B. and S. Taylor (2004) “Trade, Growth and the Environment”, *Journal of Economic Literature*, Vol. XLII (March), pp: 7-71;
- Cretegny, L. (2002) “Modelling the multifunctionality of agriculture in a CGE framework”, paper presented at the International Conference on Policy Modelling, Brussels, July 4-6;
- Dean, J. (2000) “Does Trade Liberalization Harm the Environment? A New Test”, CIES Policy Discussion Paper 0015, Centre for International Economic Studies, University of Adelaide;
- EC (2004) “Impact Assessment: Next Steps – In support of competitiveness and sustainable development”, Commission staff working paper, SEC (2004) 1377, Brussels: European Commission;
- EC (2005) “The 2005 Review of the EU Sustainable Development Strategy: Initial Stocktaking and Future Orientations”, Communication from the Commission to the Council and the European Parliament, COM (2005) 37 final, Brussels: European Commission;

FAO (2003) "WTO Agreement on Agriculture: The Implementation Experience – Developing Country Case Studies", Food and Agriculture Organisation (FAO), Rome;

Ferguson, L., McGregor, P., Swales, J.K, Turner, K. and Y. Ping Yin (2005) "Incorporating Sustainability Indicators into a Computable General Equilibrium Model of the Scottish Economy", *Economic Systems Research*, vol.17 (2): 103-140;

George, C. and C. Kirkpatrick (2003) "Putting the Doha Principles into Practice: the Role of Sustainability Impact Assessment", in Katrak, H. and R. Strange (eds.) *The WTO and developing countries*, London: Palgrave Macmillan, pp. 315-338;

George, C. and C. Kirkpatrick (2004) "Trade and Development: Assessing the Impact of Trade Liberalisation on Sustainable Development", *Journal of World Trade* 38(3), pp. 441-469;

Glebe, T. (2003) "Assessing the agricultural trade and environment interaction: taking stock and looking ahead", TUM Discussion paper 02-2003, Technische Universität München;

Grassini, M. (2004) "Rowing along the Computable General Equilibrium Modelling Mainstream", paper presented at EcoMod conference on "Input-Output and General Equilibrium: Data, Modeling, and Policy Analysis", Brussels, September 2-4;

Humphreys, N. M. (2000) "A poverty focused CGE model for South Africa", working paper, Oxford University <http://www.columbia.edu/~mh2245/papers1/>;

Kehoe, P. and T. Kehoe (1994) "A Primer on Static Applied General Equilibrium Models". *Federal Reserve Bank of Minneapolis Quarterly Review*, vol.18, no.1;

Kirkpatrick, C. Lee, N. and Morrissey, O. (1999) *WTO New Round: Sustainability Impact Assessment Study*, Phase One Report, IDPM, University of Manchester;

Kirkpatrick, C., George, C. and S. Scricciu (2004) "The Implications of Trade and Investment Liberalisation for Sustainable Development: Review of Literature", report for the UK Department of Environment, Food and Rural Affairs (Defra), July ;

Kousnetzoff, N. and S. Chauvin (2004) "Workshop summary: Methodological Tools for Assessing the Sustainability Impact of the EU's Economic Policies, with Application to Trade Liberalisation Policies", *Économie Internationale* no.99, 3^e trimestre, pp: 81-89;

Lee, N. and C. Kirkpatrick (2001) "Methodologies for Sustainability Impact Assessments of Proposals for New Trade Agreements", *Journal of Environmental Assessment Policy and Management* vol. 3, no.3, pp.1-19;

Löschel, A. and M. Mraz (2001) "EU Enlargement and Environmental Policy", ZEW Discussion Paper no.01-52, Centre for European Economic Research (ZEW), Mannheim;

Mathiesen, L. (1985) "Computation of Economic Equilibrium by a Sequence of Linear Complementarity Problems", *Mathematical Programming Study*, 23, 144-162;

Mbabazi, J. (2002) "A CGE analysis of the short-run welfare effects of tariff liberalisation in Uganda", WIDER Discussion Paper 2002/114, United Nations University;

McKittrick, R. R. (1998) "The econometric critique of computable general equilibrium modelling: the role of functional forms", *Economic Modelling* 15 (4): 543—573;

Nijkamp, P., Wang, S. and H. Kremers (2005) "Modeling the impacts of international climate change policies in a CGE context: The use of the GTAP-E model", *Economic Modelling* 22 (5): 955-974;

Paltsev, S. (2004) "Moving from Static to Dynamic General Equilibrium Economic Models (Notes for a beginner in MPSGE)", Technical Note No.4, Joint Program on the Science and Policy of Global Change, Massachusetts Institute of Technology, Cambridge;

-
- Panagariya, A. and R. Duttagupta (2001) "The 'gains' from preferential trade liberalization in the CGE models: Where do they come from?", chapter 3 in S. Lahiri (ed.) *Regionalism and Globalization: Theory and Practice*, London and New York: Routledge, pp. 39-60;
- Perroni, C. and R. Wiggle (1994) "International Trade and Environmental Quality: How Important are Linkages?", *Canadian Journal of Economics* 27(3): 551-567;
- Piazolo, D. (2001), "Investment Behaviour in Transition Countries and Computable General Equilibrium Models", *Applied Economics* 33, 829-837;
- Shoven, J. and J. Whalley (1984) "Applied general equilibrium models of taxation and international trade: an introduction and survey", *Journal of Economic Literature*, vol.22 (3): 1007-1051;
- Söderbaum (2000) "Ecological Economics: a Political Economy Approach to Environment and Development", Earthscan Publications;
- Soros, G. (1990) *Opening the Soviet System*, Weidenfeld & Nicholson;
- Surowiecki, J. (2005) "The Wisdom of Crowds: Why the Many are Smarter than the Few", London: Abacus;
- Townsend, B. and R. Ratnayake (2000) *Trade Liberalisation and the Environment. A Computable General Equilibrium Analysis*, World Scientific, Singapore;
- Turner, K. (2002) "Speculations on weak and strong sustainability", CSERGE working paper GEC 92-96, Centre for Social and Economic Research on the Global Environment, University of East Anglia and University College of London;
- Zhu, X. and E. van Ierland (2001) "Effects of the Enlargement of EU on Trade and the Environment", Working Paper no.54, Fondazione Eni Enrico Mattei, Milano;