APPLIED GENERAL EQUILIBRIUM MODELLING:

HOW EFFECTIVE IN ASSESSING SUSTAINABILITY OUTCOMES OF POLICY MEASURES? [1]

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Abstract

Applied general equilibrium (AGE) modelling represents a powerful tool for hypothesising possible sustainability outcomes that might be triggered with the implementation of specific policy proposals. They represent a useful and flexible analytical device that entails the main advantage of addressing the workings of an economy in an integrated manner and allows for feedback and spill-over effects between production sectors, households and institutions. Nevertheless, this AGE modelling is based on several tight general equilibrium economic theoretical assumptions that make their application to the assessment of all three pillars of sustainability questionable. For example, classical AGE assumptions include perfect competition, full employment of resources, market clearance conditions, the fact that the same unit of factor cannot be employed in two different places, or the fact that households cannot spend more than they earn. Although most of these assumptions have been relaxed in recent and more advanced AGE models, further research needs to be undertaken in order to bring model specifications closer to realistic behavioural relationships characterising in particular transitional or developing economies. AGE models might be associated with other shortcomings such as the "black box" critique, weakness in dealing with structuralist details, and the borrowing of parameter estimates from the literature. They 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, AGE models inherently face severe and even more profound rigidities when attempting to deal with environmental and social effects. Nevertheless, some authors have argued that AGE modelling may provide a suitable backbone for the impact assessment of all economic, environmental and social components of sustainable development. This paper takes a different stand and supports the view that though AGE models may provide some useful information on individual and in particular economic impact aspects of policy reforms, it may be inappropriate and even misleading to rely heavily or solely on their use in evaluating sustainability outcomes. In other words, the effectiveness of AGE models in providing useful and consistent insights into the overall sustainability impact assessment of policy proposals is seriously questioned here.

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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" (Bruntland, 1987). The need to provide a systematic and rigorous analysis of the effects of major policy changes on sustainability outcomes has gained since increasing importance.

This need is being increasingly met through the ongoing development of an integrated Sustainability Impact Assessment (SIA) methodological framework, initiated in late 1990s in Kirkpatrick, Lee and Morrisey (1999).[3] The SIA methodology 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 applied to trade negotiations and trade liberalisation measures.[4] 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 it considers in addition to the identification of potential effects, the assessment of likely trade-offs and adoption of accompanying measures that allow for both the enhancement of positive effects and the mitigation of negative effects (George and Kirkpatrick, 2004).[5]

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

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[3] The SIA methodology was originally developed at the Institute for Development Policy and Management, University of Manchester at the initiative of the European Commission. *Ex-ante* assessment of policies have emerged since the late 1990s, when the European Commission geared its efforts towards incorporating environmental and social concerns into its policies (as a result of Agenda 21 and Rio Declaration that promoted the concept of sustainable development) (European Commission, 2004).

[4] SIA studies include assessments undertaken at multi-national and national level such as those conducted by the European Commission (2005) for the appraisal of EU major policy proposals (also known as extended impact assessments, ExIA), Kirkpatrick, George and Scrieciu (2004) for DEFRA that fed into the UK government DTI White Paper on trade and investment, Cherp, George and Kirkpatrick (2004) for the assessment of national sustainable development strategies in transition economies, and Lee and Kirkpatrick (2001) and George and Kirkpatrick (2003) for the appraisal of the Doha Development Agenda forwarded by the World Trade Organisation.

[5] A further important feature of the SIA methodology is that is 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, *i.e.* 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).

potential trade-offs between the economic, social and environmental pillars of sustainability may be most adequately addressed through the use of numerical modelling techniques, particularly computable/applied general equilibrium models (AGE).[6]

The paper focuses on this particular methodological aspect of Sustainability Impact Assessment and investigates to what extent AGE modelling may be capable or not of adequately addressing the interdisciplinary potential criteria of the SIA process. In other words, it critically evaluates the proposition forwarded in the literature advocating the use of Applied General Equilibrium models as an analytical framework suitable for effectively assessing sustainability outcomes of policy interference.

The paper is structured into four sections. The following section briefly discusses the use of applied general equilibrium models for policy analysis. Section 3 evaluates to what extent the literature on AGE modelling have addressed SIAs. It offers a critical stand on the appropriateness of using AGE models as a backbone tool or background analytical framework for SIA and emphasises their main limitations. Section 4 concludes.

2. AGE Modelling: Theoretical and Operational Issues

Applied general equilibrium modelling represents a powerful tool for hypothesising possible outcomes that might be triggered with the implementation of specific policy proposals. It has proved to be a useful and flexible analytical device for distinguishing between the multiple economic effects that might be brought about by the implementation of a set of combined policy issues, particularly tax, trade, and more recently, environmental regulations. They 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.

AGE models 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). 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. The theoretical underpinning of AGE

[6] In this paper the term AGE (applied general equilibrium) is employed rather than the commonly used CGE (computable generally equilibrium). This is because the aim of such models is to turn the Walrasian GE theoretical structures "from an abstract representation of an economy into realistic models of actual economies" (Shoven and Whalley, 1984).

models hence "combines behavioural assumptions on rational economic agents with the analysis of equilibrium conditions" (Böhringer and Löschel, 2004). 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, AGE methodology allows models of large dimensions to be quantitatively solved whilst retaining the basic general equilibrium structure of their theoretical counterparts (Glebe, 2003).

A more complete definition may thus present an AGE 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 so that it renders an all-markets clearing equilibrium numerical solution. That is why AGE modelling represents an appropriate approach for simulating possible economic outcomes that might be triggered by given policy shocks. For this reason 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 seek their potential effect. In other words, the aim of AGE modelling is "… to evaluate policy options by specifying production and demand parameters and incorporating data reflective of real economies" (Shoven and Whalley, 1984).

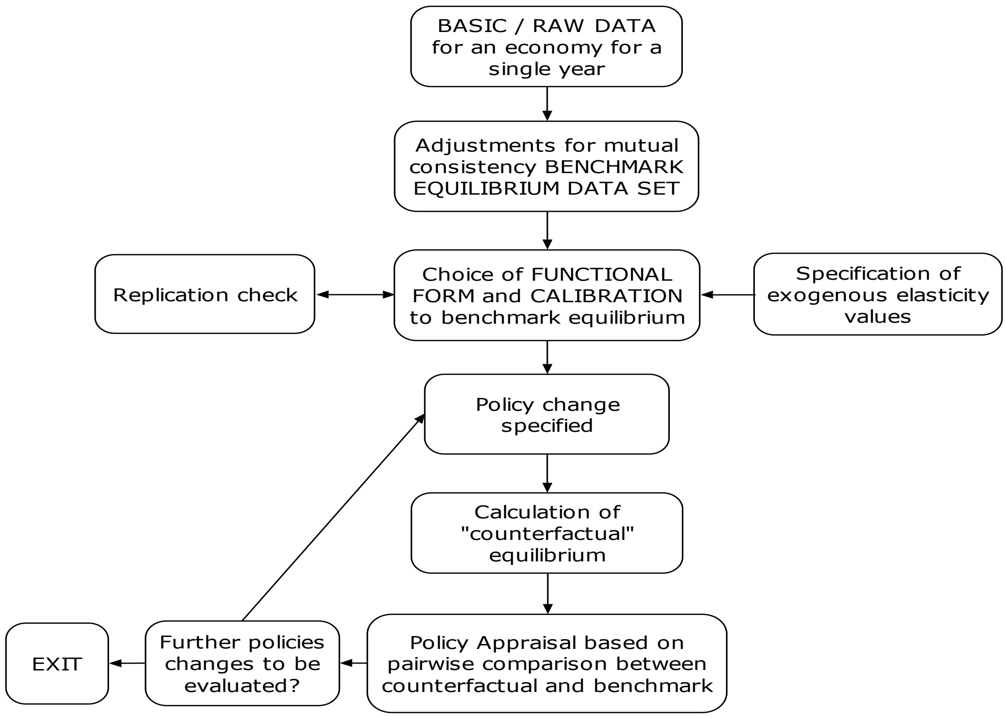
Numerical AGE models are based on classical analytical equilibrium models (formalised by Arrow and Debreu in the 1950s), according to which a unique general equilibrium solution in competitive markets may arise if three equilibrium conditions are simultaneously satisfied (Mathiesen, 1985, Paltsev, 2004):

1. *Zero profit condition* requiring that any activity operating at a positive intensity must earn zero profit.
2. *Market clearance condition* requiring that supply and demand for any good, serivce and factor of production must balance.
3. *Income balance condition* requiring that for each economic agent the value of income must equal the value of factor endowments.

However, AGE 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.[7] 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. For instance, an applied general equilibrium framework can model several taxes that are applicable to different sectors within an economy, providing the modeller with significant detail regarding feedback effects of specific tax policy initiatives (Shoven and Whalley, 1984).

Some operational aspects pertaining to the set-up of AGE models are further discussed in a nutshell. This allows the non-model user to gain key insights into the workings of general equilibrium theory practically applied to policy analysis. The steps necessary for building an AGE model and running policy simulations are illustrated in figure 1 below, based on Showen and Whalley (1984).

Figure 1: Flow chart associated with AGE model implementation



Source: Shoven and Whalley (1984)

[7] 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.

First, an organised dataset is required so that it consistently depicts an economy fulfilling the three main previously mentioned equilibrium conditions. This represents the benchmark equilibrium dataset also known in the modelling literature as the Social Accounting Matrix (SAM) that underlines the numerical framework necessary to develop economy-wide AGE models. The next step is to set the functional form of the modelled economy and to compute its parameters based upon the benchmark equilibrium values. The latter is known as calibration and represents a deterministic procedure that does not allow for the statistical testing of the model specification (Böhringer, 2004). Its purpose is to feed the calculated parameter values into the specified model that combined with exogenous elasticity values (taken from the literature) replicate the initial benchmark equilibrium. In other words, the replication check represents a test of verifying whether the model was correctly specified and parameters rightly calibrated. Finally, once the baseline data is replicated, various policy changes may be simulated, the associated counterfactual equilibria may be calculated, and the assessment of policy reforms or proposals may be undertaken based on a pair-wise comparison between the counterfactual (or alternative) scenario and the baseline.

AGE modelling hence represents a flexible and useful 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). AGE models also entail the main advantage relative to their partial equilibrium counterparts 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. They do offer the analytical strengths of a versatile empirical simulation lab and may adequately illustrate and evaluate a multitude of policy driven-interactions between economic forces.

3 AGE Modelling and Sustainability Impact Assessment

The modelling literature dealing with interactions between all three economic, social and environmental components of sustainable development is extremely sparse. This is largely because both the SIA concept and AGE economic modelling techniques to include environmental and social indicators have only recently emerged. And it may also be attributed to the limited capability of such a numerical modelling approach to effectively undertake integrated SIAs. However, there are several studies that model the impact of policy changes on individual relationships/aspects of the sustainability process, e.g. issues pertaining to economic and environmental development or between economic and social aspects.

3.1 Addressing sustainability with AGE models

On one hand, for example, an increasing number of studies address the relationship between greater trade liberalisation and environmental performance. These are performed at various aggregation levels, from a global perspective (Perroni and Wiggle, 1994, Espinosa and Smith, 1995, Cole and Rayner, 2000, and Copeland and Taylor, 2004), 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). Their modelling approach generally attaches an environmental module to production or consumption functions often under the form of technical coefficients of emissions. On the other hand, a growing body of AGE 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. The author argues that there are only minimal welfare gains from trade liberalisation, in particular in favour of agricultural households.

Consequently, in order to attain household welfare maximisation and to provide equitable gains to the poor, developing countries need, from the author's point of view, to promote other complementary policies besides trade liberalisation measures, such as government and intra-household transfers, and reduced transportation costs. Humphreys (2000) also evaluates within an AGE modelling framework poverty and distributional impacts of trade liberalisation in South Africa and finds that though reducing tariffs in the protected sectors tends to decrease poverty in absolute terms (by raising the income of both the poor and the non-poor) it fosters an increase in inequality. Coady and Harris (2004) adopt an augmented AGE approach[8] that addresses the welfare impact of cash transfers targeted at rural areas in Mexico, and find that whilst the direct impact of transfers overall decreases regional income differentials, the indirect aggregate and regional effects depend on the efficiency of the tax system used to finance the respective transfers.

Nonetheless, the paper does not go into more detail pertaining to the above-mentioned literature, which tends to address only individual components of sustainability. This is 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 paper

[8] 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).

hence focuses on studies that have attempted to use AGE modelling as an exclusive tool in providing an integrative assessment of the sustainability dimension. More precisely, the paper further puts forward a detailed critical discussion of the approach undertaken in Böhringer and Löschel (2004) and further pursued in Böhringer (2004), which insofar appear to be the only studies that argue for the particular suitability of applied general equilibrium models as an appropriate integrated methodological approach for measuring the three pillars of sustainable development.

3.2 The Böhringer studies

Böhringer and Löschel (2004) presents the case for the use of Applied 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 author asserts that AGE modelling may represent a good fit of the requirements for a comprehensive Sustainability Impact Assessment (SIA).[9] The study argues that:

> "[…] computable general equilibrium models can incorporate several key sustainability 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)

The authors start their arguments by displaying two lists of policy-relevant systems of sustainable indicators that may be partially addressed within an AGE 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 scope of evaluating the progress of the EU towards sustainable development (as outlined in its *Strategy for Sustainable Development* formulated at the Göthenburg Summit in 2001). Both sets of indicators of sustainable development are constructed with the scope of being used at a national level. 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

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

corresponding sustainability measures. The list forwarded by the European Commission encompasses only 14 structural indicators that facilitate the process of evaluating the progress made by EU member states towards sustainable development.

A large part of these sustainability indicators may then be included according to Böhringer and Löschel (2004) within an AGE modelling framework. This would eventually provide a quantitative approach to SIA and lead to better-informed policy decision-making rather than on "fuzzy or contradictory hunches" (Böhringer, 2004). The authors develop a standard ("core") AGE 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. No change in the employment of resources, constant returns to scale and perfect competition are generally associated with standard AGE models. In a standard model output is derived from a Leontief combination (*i.e.* 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.

However, the core model has limited application for SIA purposes in the sense that besides the fact that it addresses only the economic and environmental components,[10] when it comes to the latter it provides only a quantitative assessment in terms of emissions from fossil fuel combustion (namely, CO_2) and may simulate only a very narrow spectrum of environmental policy responses such as a carbon tax. In Böhringer and Löschel (2004), a series of extensions are discussed 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-CO_2 greenhouse gases, accounting for market distortions such as taxes or subsidies, involuntary unemployment and imperfect competition, adding dynamic specifications and endogenous technological change, the diaggregation of the representative agent into heterogeneous households that would allow for the analysis of equity issues, as well as linking models to ensure a more comprehensive coverage of SIA requirements. The authors appropriately acknowledge what type of indicators the approach cannot incorporate and address problems of quantification relatively well. They do not provide, however, greater detail with

[10] The core model includes in its framework only 6 (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 58 indicators on the United Nations CSD list and 4 (GDP per capita, labour productivity, greenhouse gas emissions and energy intensity of the economy) out of the 14 structural indicators on the European Commission's list.

regard to their practical implementation and pros and cons associated with the extended counterparts of a standard AGE model to address SIAs.

Nevertheless, a more detailed explanation of possible AGE methodological extensions and their relevance for SIA is put forward in Böhringer (2004). The author acknowledges that one of the main weaknesses of AGE numerical modelling is that it is very difficult to distinguish between the numerous general equilibrium effects driving simulation results, i.e. "the black box critique". He then presents in more depth two alternative decomposition techniques that would tackle the black box critique and identify the economic channels through which international trade may transmit policy impacts. Further extensions to the core AGE model are represented in Böhringer (2004) in terms of specifying and solving optimal policy problems, or undertaking systematic sensitivity analysis for key elasticities. Nonetheless, though the proposed extensions to the core model are essential for a rigorous and robust AGE analysis in general, they once again do not particularly address sustainability issues. Such proposals of model development are extremely welcome in the modelling literature and may apply to the policy analysis of various individual aspects of development. However, they do not necessarily and explicitly allow for an adequate assessment of particularly the environmental and social components of sustainable development or of the development process per se. This is largely due to the inherent limitations and drawbacks that AGE modelling entails when it comes to effectively address SIA.

4. Limitations and Drawbacks of AGE Modelling for an Effective SIA

At first glance, AGE modelling, 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 applied 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 pertaining to the nature of the modelling methodology is that AGE models represent a policy simulation tool and solely focus on providing quantitative estimates of various indicators. However, though the need to deliver robust and rigorous quantitative SIAs is heavily advocated, at the same time it is increasingly acknowledged that several environmental, social and even economic aspects of sustainable development are very difficult (and in some cases not even desired) to be quantitatively estimated. For example, in a multitude of cases the natural capital may display an intrinsic value and integrating it within a pricing system based on individual preferences may actually be in conflict with ecological concerns.[11] The difficulty of mathematically formulating and quantifying interactions between economic activities and 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 (*e.g.* biodiversity), elements of the relationship that may be adequate for modelling continue to be the focus of intense discussions amongst modellers.[12]

This leads us to the second argument pertaining to the theories underpinning this type of quantitative approach to evaluation. The entire AGE modelling framework heavily draws for instance on neoclassical economics that tends to explain economic and recently even social and environmental phenomena based upon the theory of optimisation behaviour of rational economic agents. 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, objective, monetary reductionist approach that places a strong emphasis on the market as the solution to all kind of problems (including environmental and social issues).

The neoclassical approach in other words fails to appropriately account for the institutional arrangements, ethical issues and the needs of a society within an interdisciplinary, pluralistic and holistic approach to the development process. When economic and environmental linkages are assessed within an AGE 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 theoretical assumptions also argue that individual behaviour reflects the rational pursuit of self-interest, and consequently, the optimal policy would be represented by that that best allows individuals to maximise their personal utility

[11] 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).

[12] 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, *i.e.* 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 authors 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.

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[13] (labelled by Amartya Sen as meta-preferences or second-order preferences as opposed to first-order preferences derived from the standard "rational" economic behaviour). These assertions may open a Pandora's box[14] and hence to keep this section in manageable limits the paper next addresses more specific problems pertaining to AGE modelling.

A further critical issue again relates to the theory underlining AGE models, that of general equilibrium (GE) and the AGE 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 AGE models assumes that there is complete information about all prices now and in the future, and that economic agents implicitly have unlimited computational abilities, a long way from describing the workings of real economies. Although most of these assumptions have been relaxed in recent and more advanced AGE models, further research needs to be undertaken in order to bring model specifications closer to realistic behavioural relationships characterising in particular transitional or developing economies.

Moreover, market clearing conditions and the GE rule that every source needs to find a sink (e.g. 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. For example, general equilibrium modelling mainly produces a static equilibrium, whereas an open society is bound to be 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 assumption of a steady-state equilibrium becomes even less plausible in the case of developing or transition economies that continue to undergo rapid and substantial changes (the so-called "transition" handicap outlined in Piazolo, 2001).

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[13] 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.

[14] The theory of optimisation behaviour represents a very specific view of human beings, society and nature, and other theoretical perspectives in both economics and other social sciences tend to be excluded. In other words, following the path of objectivity (*i.e.* 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.

Furthermore, though more recent developments in AGE modelling allows for the insertion of dynamic elements, these are limited in scope and provided an unsatisfactory description of dynamism within an economy.[15] For instance, AGE 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. Other disadvantages associated with the workings of AGE modelling include the "black box" critique pertaining to often 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,[16] 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.[17]

Finally, the very nature of AGE 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 differences between political, social, cultural, environmental and even economic country-specific settings. For instance, with regard to the economic background of a nation, AGE 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, AGE models reduce it to employment and equity concerns (as argued in the Böhringer studies) without consideration for other major social issues such as education, health or justice. 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 AGE modelling undertakes and its tendency to work at high levels of aggregation. Nonetheless, the insertion of household economic models within a general

[15] 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).

[16] In other words, various parameters are derived from mathematical manipulation (calibration) and are not estimated from statistical fittings of empirical.

[17] The entire AGE 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).

equilibrium framework (often referred to as "augmented" AGE 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 for example more relevant extensions to AGE models for SIA than those proposed in the Böhringer studies

5. CONCLUSIONS

The paper critically discussed the appropriateness and selective focus on applied general equilibrium models to effectively provide consistent insights into the overall sustainability impact assessment of policy proposals. The AGE numerical approach may provide a systematic and rigorous quantification of potential trade-offs and interactions of the many forces operating in an economy. Nonetheless, though AGE models may render useful information on individual and in particular economic aspects of policy reforms, they appear to not 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 AGE 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.

Using AGE modelling as a backbone for SIA may lead to the domination of an exclusively quantitative technique that heavily draws on the monistic view of neoclassical economics regarding human behaviour. This may seriously infringe upon the very 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 AGE 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.

Researchers may respond better to sustainable development needs by further refining and consolidating the SIA methodological framework. This may involve for example the search and identification of an appropriate mix or blueprint of tools and approaches that would not overlook real problems of society at large and deliver more comprehensive answers on how to reconcile economic development, social cohesion and environmental protection. In order to achieve this, researchers would need to assent that to design and implement adequate enhancement and mitigation measures, tradeoffs need to be systematically and rigorously quantified, and general equilibrium modelling techniques may represent a good fit for some individual aspects of interactions. However, researchers would also need to acknowledge that other quantitative approaches may be more adequate in assessing other aspects of SIAs, and furthermore, that there are issues that are difficult or inappropriate to measure, which also may be subjected to improvement.

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, 3e trimester, 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 D.C.
- 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 prepared for presentation at the International Conference on Policy Modelling, Brussels, July 4-6
- Espinosa, J. and V. Smith (1995) "Measuring the Environmental Consequences of Trade Policy: A Nonmarket CGE Analysis", *American Journal of Agricultural Economics* 77(3): 772-777
- European Commission (2004) "Impact Assessment: Next Steps – In support of competitiveness and sustainable development", Commission staff working paper, SEC (2004) 1377, Brussels
- European Commission (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
- 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
- FAO (2003) "WTO Agreement on Agriculture: The Implementation Experience – Developing Country Case Studies", Food and Agriculture Organisation (FAO), Rome;

- 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*, (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
- Humphreys, N. M. (2000) "A poverty focused CGE model for South Africa", working pape, 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. Scrieciu (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 (http://statistics.defra.gov.uk/esg/reports/implications/default.asp)
- 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, 3e trimester, 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
- 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;
- 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* no.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
- 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
- World Bank (2003) *A User's Guide to Poverty and Social Impact Analysis*, World Bank, Washington D.C.