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Methodological Tools for SIA

Report of the CEPII Worshop held
on 7-8 November 2002 in Brussels

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
FOR RESEARCH

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METHODOLOGICAL TOOLS FOR ASSESSING THE SUSTAINABILITY IMPACT OF THE EU'S ECONOMIC POLICIES, WITH APPLICATIONS TO TRADE LIBERALISATION POLICIES

REPORT OF THE CEPII WORKSHOP HELD ON 7-8 NOVEMBER 2002 IN BRUSSELS

FOREWORD [1]

Sophie Chauvin, Nikolaos Christoforides and Nina Kousnetzoff [2]

In 2002, the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) organised a Workshop on the **"Methodological Tools for Assessing the Sustainability Impact of the EU's Economic Policies, with Applications to Trade Liberalisation Policies"** with the support of the European Commission, Global Change and Ecosystems Programme of the Directorate General for Research. This event was part of the European Commission's Fifth Framework Programme, "Socio-economic Aspects of Environmental Change in the Perspective of Sustainable Development". The organisation of the Workshop was also encouraged by the Directorate F of the Directorate-General for Trade. The principal aim of this exploratory Workshop was to strengthen methodologies for integrating the social, economic and environmental dimensions of sustainable development. It also aimed at developing modelling tools for policy-makers involved in Sustainability Impact Assessments (SIA).

The Workshop took place on 7th to 8th November 2002, in Brussels. It reviewed the methodologies and tools to be developed for the SIA of economic policies. More specifically, the communications and discussions focused on quantitative assessments of sustainability impacts, applied to multilateral economic policies of the European Union, and especially its trade liberalisation policies; the use of Computable General Equilibrium Models, linked to sectoral partial equilibrium models; as well as sectoral analysis and environmental indicators. The three pillars of sustainable development — economic, social and environmental — were considered. Importance was given to the fields in which quantitative results are scarce or still open to question.

The Workshop identified the methodological problems and issues which require further research to improve both the theoretical basis and the operational effectiveness of SIA tools. It is expected that the results obtained by the participants will be incorporated in future working programmes.

1 The authors thank Mohamed Hedi Bchir, Economist at the CEPII, for assistance in editing these proceedings.

2 Sophie Chauvin is an Economist at the CEPII; Nikolaos Christoforides is a Scientific Project Officer at the European Commission, Directorate-General for Research, Strategy and Policy for Sustainable Development; Nina Kousnetzoff is a Senior Economist at the CEPII.

This volume contains the proceedings of this Workshop, including a Summary, revised versions of six communications, comments on the SIA tool currently used by the European Commission, and discussions of the concluding Round Table. The original communications to the Workshop are available on www.cepii.fr

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WORKSHOP SUMMARY[3]

Nina Kousnetzoff and Sophie Chauvin[4]

1. BACKGROUND AND OBJECTIVES

The Workshop Methodological Tools for Assessing the Sustainability Impact of the EU's Economic Policies, with Applications to Trade Liberalisation Policies took place on 7th to 8th November 2002 in Brussels. It was organised by the CEPII with the support of the European Commission, the Directorate General for Research's Global Change and Ecosystems Programme. The organisation of this Workshop was also encouraged by the EC Directorate General for Trade. The three half-day sessions were chaired by Robert Madelin, Director, DG Trade; Katheline Schubert, Professor at the University of Paris I; and Robert Teh, Counsellor at the Development and Economic Research Division of the World Trade Organisation. Opening addresses were given by Lionel Fontagné, Director of the CEPII, Robert Madelin, and Pierre Valette, Head of the Strategy and Policy for Sustainable Development Unit, DG Research. A keynote address was given by Pierre Defraigne, Deputy Director General of DG Trade. The sessions were followed by a concluding round-table for policy-makers, chaired by Pierre Valette. Some 50 people participated in this workshop, including academic experts from Europe and the US, senior policy officials of the Commission, and representatives from Member States, intergovernmental organisations, non-governmental organisations, and the civil society. The programme, the abstracts of the communications and the list of participants are provided in the Annexes.

The general aim of this exploratory Workshop was to strengthen methodologies for integrating research on the social, economic and environmental dimensions of sustainable development. It also aimed at defining the characteristics of innovative modelling tools for policy-makers involved in Sustainability Impact Assessments.

The purpose of SIAs is to inform policy-makers in advance of the policy consequences on sustainable development. It was recalled that the WTO Ministerial Conference at Doha in 2001 confirmed that sustainable development should be an over-arching goal of WTO trade negotiations and encouraged the efforts by its members to conduct national environmental assessments of trade policies.

Moreover, a Communication from the European Commission on Impact Assessment was published in June 2002, in which the Commission announces its intention to launch impact assessments as a tool to improve the quality and coherence of the policy development process. Gradually, from 2003, all major policy initiatives will be subjected to the new

[3] The authors are grateful to Lionel Fontagné for his support in the organisation of the Workshop and his comments on the papers, and to Sébastien Jean for his comments on this Summary.

[4] Nina Kousnetzoff is a Senior Economist at the CEPII; Sophie Chauvin is an Economist at the CEPII.

sustainability impact assessment method ("Phase III") elaborated by the Institute for Development Policy and Management of the University of Manchester (IDPM).

This tool, which was presented at the Workshop, is currently used to analyse the SIA of proposed WTO multilateral trade negotiations. The main stages of the "Phase III" process include analysing the proposed trade measures, then selecting methods, data sources and indicators, in order to provide concrete inputs for negotiators to modify policies, including flanking measures to mitigate potential negative impacts or enhance positive ones. To enable sustainability appraisal to be taken into account by negotiators before reaching agreement, the SIA schedule is to be correlated with the negotiations. In each particular case, the combination of methods to be used differs depending on the information at hand; quantitative methods can be used only if sound data are available; otherwise other approaches, such as thorough consultation of experts and stakeholders, should be favoured. Thus the "Phase III" tool demonstrates a well-tried procedure for the SIA of trade liberalisation negotiations. But it is still at a formative stage regarding the analysis of trade liberalisation or other policies effects on sustainable development, and the use of quantitative tools and indicators. The other communications at the Workshop brought insights into these theoretical and practical problems, provided state-of-the-art literature reviews, and added useful comments regarding the procedural aspects of SIAs. Finally, some items on which more research is needed were pointed out.

2. THEORETICAL EFFECTS OF TRADE LIBERALISATION ON SUSTAINABLE DEVELOPMENT

Sustainable development can be defined as a long term harmonious process where economic performance, or efficiency, is increasing, while securing environmental quality and complying with equity concerns. Trade liberalisation and sustainable development are two explicit objectives of the international community which are not necessarily compatible: the elimination of trade distortions eventually increases economic efficiency, but the effects of this increase on the environment and the social conditions are ambiguous. Moreover, concerning economic efficiency, trade liberalisation should provide global welfare gains once all factors of production have found new long run occupations, but generates social adjustment costs during the transition period. In addition, it may have significant internal, distributive impacts.

The purpose of SIAs is to take into account, and if possible to measure, on top of the long term welfare gains, all the other positive or negative effects of the modifications in trade flows, patterns of production, consumption and investments resulting from a policy change.

Economic and social impacts

Firstly, redirecting resources between sectors and companies may result in temporary economic losses during the transition period. These social adjustment costs amount to the value of output that is foregone, because of the change. The importance of these costs is under debate. They are often considered as negligible when compared to the potential welfare gains. Other economists consider that transition dynamics are fundamental, because the real world actually consists of a succession of transitions, and a steady state is never achieved. Introducing more flexibility in labour, financial and other markets (e.g. the housing market) may reduce this frictional underemployment of production factors. In contrast, concerning private adjustment costs, there is a fair amount of empirical evidence that trade liberalisation may entail significant economic losses for some groups, as well as important immaterial costs, such as psychological distress, which are difficult to measure.

Secondly, trade liberalisation may have significant distributional impacts across labour categories. In particular, the Stolper-Samuelson theorem states that, by lowering the price of unskill-intensive goods, trade with low-wage countries may lower unskilled labour wages in Northern economies. This does not mean that trade with developing countries should be considered as the culprit for increased inequalities in developed countries, but it outlines the possible impact of trade liberalisation. The adequacy of this simple theoretical framework is questionable. In imperfectly competitive frameworks, similar relationships between trade liberalisation and wage or employment inequalities also show up, but the conclusions to be drawn remain ambiguous.

Environmental and equity impacts

Participants noted that some theoretical results should be questioned, as the empirical literature shows contradictory evidence. One example is the environmental "Kuznets curve", which suggests the existence of an inverted, U-shaped relationship between the level of damage and the level of income. Another example is the pollution-haven hypothesis, which indicates that strict environmental standards reduce producers' competitiveness and is leading to relocation of polluting activities abroad.

As for equity issues, the impacts of trade liberalisation on inequality and poverty are difficult to distinguish from other effects, and the evidence accumulated by the empirical literature is contradictory. At least it seems that increases of per capita income are not sufficient to eradicate poverty.

The measurement of these effects also poses a number of problems. Firstly, the concept of sustainable development is too wide to make overall SIAs operational. Secondly, the environmental and equity components of sustainable development may be situated outside the economic field. It is sometimes considered that they have a normative dimension which cannot be reduced to economic efficiency requirements. In any case the evaluation of such effects as, for example, damage to the environment or changes in women's activity at home, is not straightforward. Thirdly, damage to the natural environment may be irreversible, beyond certain thresholds. Some participants considered that all this makes it very difficult to establish cost-benefit balances between economic welfare gains and the impacts on the other components of sustainable development. However, other participants pointed out that the three dimensions of sustainable development are inherently subject to trade-offs: the assessment of external costs or benefits is a prerequisite towards "getting the prices right", which should solve the sustainability problem.

Time dimension

According to the Brundtland Report[5], sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs". The SIAs should take into account this time dimension, comparing the short term and long term effects of a policy. Some examples were provided by the participants. Regarding the impacts of trade liberalisation in agriculture on the environment, short term improvements, in some instances, such as reduced pollution, should be compared to long term damage, such as land degradation or resource depletion. Similarly, regarding the impacts of trade liberalisation on gender inequality, it is necessary to distinguish between short term effects which modify the current material status of women ("practical gender needs"), and long term effects which modify gender division of labour ("strategic gender needs"). In the economic field, it is also difficult to compare short term temporary social adjustment costs, and long term permanent welfare gains.

The need for empirical studies

As theoretical predictions of the impacts of trade measures on sustainable development are ambiguous, it is necessary to turn to empirical studies and detailed data collection to feed ex-ante, computable models. Some concrete examples were provided by the participants.

One example is the agricultural sector, where the relationships between shifts in production or consumption due to policy changes and damage to the environment are complicated and case-specific. They depend on the natural environment, the production systems, and the agricultural and environmental policies. It is necessary to go down to the regional or even the local level, in order to construct bio-physical production functions with technical coefficients of pollution emissions and physical indicators measuring land degradation and resource depletion. In the case of the European Union's enlargement programme, the lack of reliable environmental data for most of the Accession countries explains why very few general equilibrium or agricultural sector models take into consideration the environmental dimension.

Another example is gender inequality. The impacts of trade policy changes on the gain or loss of women's welfare depend on the socio-economic characteristics of the household, the sector of employment and the country. In order to capture these effects when using a Computable General Equilibrium (CGE) model, gendered social accounting matrices (SAM) must be constructed.

A third example is the assessment of social adjustment costs due to trade shocks. The magnitude of these costs depend on the mobility of production factors, and especially on labour market flexibility. A good knowledge of labour market institutions and other specificities is important to choose realistic values for these parameters in *ex-ante* studies.

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[5] UN, World Commission on Environment and Development (Chair : Gro Harlem Brundtland), «Our Common Future », 1987.

A review of the empirical literature on the magnitude of adjustment costs from trade liberalisation was presented. One approach is to study outlays in national assistance schemes which accompany trade liberalisation acts. Another is to estimate the temporary income loss of displaced workers. Some studies take into account the natural rate of turnover by sector, before estimating the adjustment costs. Others estimate the share of the restructuring of trade, which takes place within sectors, because it is easier for production factors to move within the same industry.

3. EMPIRICAL PREDICTION TOOLS

A wide range of assessment methods exist which can be used in the empirical appraisal of sustainability impacts. These include: modelling, statistical estimation, descriptive case studies and consultation. The communications at this Workshop concentrated on quantitative methods. It was recalled that *ex-ante* quantitative tools include macroeconomic models, general equilibrium models, mathematical programming and eco-environmental simulation models.

The participants agreed that CGE modelling is a central methodological tool for SIA. The main advantage of these models is to account for agents' behaviour and trade-offs in a consistent framework. This makes it possible to assess, *ceteris paribus*, the impact induced by a shock in structural policy variables, such as protection or taxation. CGE modelling allows for consideration of macroeconomic effects and of linkages between sectors, showing direct effects and also feedbacks and spillovers. They cover the impacts on resource allocation and on incomes. A time dimension can be added using dynamic models, in some cases with overlapping generations (OLG). A CGEM is an open framework which can consistently incorporate a wide range of indicators. Therefore it allows for quantitative trade-off analysis, along the three dimensions of sustainable development.

CGEMs have their own shortcomings. Firstly, they are constructed using deterministic parameterisation of elasticities of response to policy shocks. Systematic sensitivity analysis is necessary to test their robustness against uncertainties in the parameterisation. Secondly, CGE models use the nation state as the unit of analysis because trade policy is made at the national level, whereas environmental or social impacts are frequently local in nature. Thirdly, standard CGEMs do not take into account financial flows such as foreign direct investments (FDI). Fourthly, the models' complexity is strongly limited by computational and data constraints. This is why most CGEMs in use are single period, static models with fixed factor endowments and technology[6]. They assess long term impacts, but do not necessarily provide information on the transition period. Unlike some advanced econometric, macro-sectoral models used by the European Commission, such as NEMESIS (New Econometric Model for Environment and Sustainable development Implementation Strategies), they do not always account for technological and knowledge spill-overs between sectors and countries.

[6] MIRAGE, developed by the CEPII, is an exception: this CGEM is of a dynamic nature (more precisely it uses recursive statics) and explicitly models FDI.

An example of a standard multi-region, multi-trade CGE model of global trade and energy use was presented. This type of model is currently used to assess the costs of greenhouse gases mitigation policies, and in particular of meeting the emission targets under the Kyoto Protocol. Even when a CGEM is devoted to one specific problem, it may be difficult to analyse the results of policy changes which bring about complex economic interactions. Different decomposition methods were presented, which can be used to clarify the analysis of the impacts. The total effect of a multiple, exogenous policy instrument may be decomposed into its various partial effects, using a generic linear decomposition methodology. This method can be used to assess the role of individual countries in multilateral contracts, such as the emission abatement commitments of the Kyoto Protocol. Other decomposition methods are used to distinguish the direct and indirect effects of policy interventions. For example, to assess the total impact of an international carbon tax using a CGEM, the simulation can be done in two steps, first keeping international energy prices constant to estimate separately the direct effect of resource reallocation on the domestic markets, and second taking into account the changes in international energy prices to estimate the international market effect of the tax.

Different solutions were proposed by the participants to construct models capable of assessing very particular impacts relevant to sustainable development. In general, these constructions include a CGE framework, with special features incorporated in the model or attached to it.

One solution is to construct more detailed databases for the CGEM. The standard databases use national accounts tables and describe one representative household per region. Extensions can be made to incorporate a larger number of indicators. For example, if the issue is gender relations, a gendered structure can be introduced in the labour force and the households. Concerning the social accounting matrices (SAM) data, by using "internal satellite accounts", a greater level of detail can be provided for existing material contained in the traditional national accounts. For instance, agricultural sectors can be further disaggregated into female-intensive and male-intensive crops. Conversely, "external satellite accounts" can be added, extending definitions of what constitutes production or assets. Examples of external satellite accounts are those which estimate environmental costs of production, and those that provide a valuation of household's own activities. The development of satellite time-use modules, which keep a record of how much time people spend on various tasks and impute a monetary value to non-market time (spent either on household activities or on leisure), is of particular relevance to gender analysis. An example was presented, comparing the potential effects of trade liberalisation on gender inequality in Bangladesh and Zambia.

Another solution is to change the core assumptions on production functions and the representation of markets in the model in order to get a more realistic measurement of policy effects. The introduction of these special features can be done either in CGEMs or in partial equilibrium models for one sector. These improvements are recommended for a better assessment of the social adjustment costs resulting from trade policy effects on output, employment and wages. An example was presented, using the Global Trade Analysis Project (GTAP) database and CGE model to simulate the impacts of the European

Union pending enlargement of the Accession countries. Monopolistic competition (replacing the Armington trade assumption) and scale economies are introduced in the industrial and service sectors. In the other sectors (agriculture and primary products), perfect competition and constant returns assumptions are maintained. A sluggish inter-sectoral mobility of labour is assumed.

In the same example, the author demonstrates how missing indicators of economic and social sustainability impacts can be incorporated in a CGEM. The standard CGEMs disregard the process required to move from the initial to the final equilibrium, and therefore ignore adjustment costs. Innovative social adjustment cost indicators were presented. They are constructed using the usual CGEM results on sectoral shifts of output and employment, resulting from a trade or other policy shocks. They could also be estimated with respect to the population of firms within a sector. These structural change indicators are defined as variance-based indices of output and employment deviation. They measure the temporary unemployment due to workers displacement and the corresponding loss in output. They are compared to the final changes in output, employment and wages. Taken all together, these indicators show the possible trade offs between adjustment costs and long term effects.

Conversely, other subjects relating to sustainable development need special models to be constructed separately from the general economic framework. For example, this applies to the environmental costs of the agricultural sector. Bio-physical agronomic models, comparable to very detailed engineering production functions, are needed to describe the technical, biological and physical process of production on a local basis. The results of these models are used to construct bio-physical agricultural production functions which provide physical environmental indicators. These models require a large amount of data. It is very difficult to generalise them on a country or regional basis, because the relationships between the levels of agricultural production and the levels of environmental damage are not straightforward. Therefore only very rough bio-physical indicators can be directly included in the trade models. Another method is to use the agricultural price and production results of the CGE trade models, as inputs to bio-economic models constructed on a country or regional basis. Bio-economic models are obtained by integrating the simulation results of the bio-physical agronomic models into economic models, such as mathematical programming models. The bio-economic models will provide information on farmers' technical changes resulting from trade or other policy measures, and estimate their environmental impacts.

Mathematical optimisation models can also be used in a CGE framework, in order to determine optimal policy choices. A relatively new research area is based on the class of mathematical programs called Mathematical Programs with Equilibrium Constraints (MPEC). The MPEC problem class permits a formal characterisation of optimal policies, within which the objective function depends on policy variables which would be exogenously specified in a conventional CGE application. The example presented at the Workshop showed that the embedding of an environmental, general equilibrium model in a MPEC framework allows optimal carbon tax programmes to be designed.

4. CONCLUSIONS FOR POLICY-MAKERS AND SUGGESTIONS FOR FURTHER RESEARCH IN EUROPE

The participants made a variety of general points regarding trade liberalisation, sustainable development and the use of sustainability impact assessments.

Concerning multilateral negotiations, it was suggested that environmental and trade negotiations should be coupled. Concerning the EU policies, some participants expressed the need for a political debate about the desirability of further trade liberalisation, and questioned the capability of states to establish mitigation measures against its negative side effects; slowing down trade liberalisation should also be considered as an option.

The usefulness, possibility and legitimacy of sustainability impact assessments were also questioned. There is no clear scientific answer for the weighting of trade offs between the various components of sustainable development; the final decision is clearly political. Moreover, it is difficult to isolate trade effects from the other globalisation phenomena, and it may be preferable to include the trade liberalisation policies in a broader framework.

The participants listed necessary conditions to produce more constructive assessments:

- SIAs should be carried out by independent institutions.
- They should be implemented well ahead of the signature of trade agreements or association agreements.
- They should assess different policy options.
- Consultations on the relevant issues should be done before starting the SIA.
- SIAs should be country specific, and consider regional and local levels.

Concerning further European research on SIA methodologies, the participants agreed on the need for interdisciplinary project teams and networks. They also agreed on the need to make substantial progress in environmental and social sustainability data collection. It was suggested that more work should be done on Third countries, and particularly on developing countries, which are more vulnerable to the environmental and social impacts of trade liberalisation and globalisation. In particular, more consideration should be given to the problem of poverty eradication. As far as the EU Member States are concerned, an important issue is the environmental effect of the Common Agricultural Policy, especially in the context of the pending membership of the Central and Eastern European Countries.

ANNEX 1.

PROGRAMME OF THE CEPII WORKSHOP ON THE METHODOLOGICAL TOOLS FOR ASSESSING THE SUSTAINABILITY IMPACT OF THE EU'S ECONOMIC POLICIES, WITH APPLICATIONS TO TRADE LIBERALISATION POLICIES

This operation has received funding from
the European Commission, DG Research, 5th Framework Programme.

THURSDAY 7 NOVEMBER 2002

9h30

Welcome and Opening Session

General introduction : Lionel Fontagné, CEPII
Opening address: Identifying the problem:
Robert Madelin, European Commission, DG Trade
Pierre Valette, European Commission, DG Research

SESSION 1: ECONOMIC ISSUES

Chair: Robert Madelin

10h45 – 11h30

1. *Sustainability Impact Assessment Methodology: SIA Study of Proposed WTO Negotiations:* Colin Kirkpatrick, Institute for Development Policy and Management, University of Manchester (IDPM)

   ***Discussant*:** Ian Volbracht, European Commission

11h30 – 12h30

2. *Assessing the Impact of Trade Policy on Labour Markets and Production:* Joseph Francois, Tinbergen Institute and CEPR

   ***Discussants*:** Ali Bayar, Free University of Brussels and René Von Schomberg, European Commission

12h30

Lunch
Keynote address : *Trade Liberalisation and Sustainable Development*: Pierre Defraigne, DG Trade, European Commission

SESSION 2 : ENVIRONMENTAL ISSUES

Chair : Katheline Schubert, Université Paris I

14h30 - 15h30

3. *Sustainable Impact Analysis: the Use of Computable General Equilibrium Models:* Christoph Böhringer, Centre for European Economic Research (ZEW), Mannheim

   Discussants: Nina Kousnetzoff, CEPII and Maria Luisa Tamborra, European Commission

15h30 – 16h30

4. *Impact of Trade Liberalisation on the Environmental Sustainability of Agriculture in the Countries Applicants to EU Accession:* Luiza Toma, Katholieke Universiteit Leuven

   Discussant: Jean-Christophe Bureau, INRA

17h00 – 18h00

5. *Building agri-environmental indicators by the integration of bio-physical and economic models for assessing sustainability of agricultural trade liberalisation:* Guillermo Flichman, Agronomic Mediterranean Institute of Montpellier (IAMM)

   Discussant: Chantal Le Mouel, INRA

FRIDAY 8 NOVEMBER 2002

SESSION 3 : SOCIAL ISSUES

Chair : Robert Teh, World Trade Organisation

9h00 – 10h00

6. *Trade Liberalisation and Inequality Between Households. A Review of the Recent Empirical Evidence:* Pier Giorgio Ardeni, Universita di Bologna

   Discussants: Marion Jansen, WTO; Maros Ivanic, Purdue University; and Nicholas Aris Charalambides, European Commission

10h00 – 11h00

7. *Modelling the effects of trade on women, at work and at home: a comparative perspective:* Marzia Fontana, International Food Policy Research Institute, Washington, DC (IFPRI)

   Discussants: Mohamed Ali Marouani, DIAL and Katri Kosonen, European Commission

11h30 – 13h00
<u>Round-Table : Conclusions for policy-makers</u>

Chair: Pierre Valette, European Commission, DG Research

Panellists: Hannan Awwad, Mediterranean Free Trade Zone Environment Watch
Jean-Baptiste Gros, International Labour Organisation
Nikolaos Kouvaritakis, National Technical University of Athens
Mireille Perrin, World Wildlife Fund International
Eric Peters, European Commission
Robert Teh, World Trade Organisation
Paul Zagamé, Université Paris I

ANNEX 2
ABSTRACTS OF THE WORKSHOP PAPERS

SESSION 1: ECONOMIC ISSUES

1. ***Sustainability Impact Assessment Methodology: SIA Study of Proposed WTO Negotiations**:*
   Colin Kirkpatrick, Institute for Development Policy and Management, University of Manchester (IDPM).

Abstract. The Doha Ministerial Declaration confirms that sustainable development should be an overarching goal of WTO trade negotiations.

It also recognises that trade can promote economic development and alleviate poverty, and it places the needs and interests of developing countries at the forefront of the WTO work programme.

This paper describes a sustainability impact assessment (SIA) methodology for appraising the impact of trade policy measures on sustainable development, and argues that it addresses many of the current issues and concerns in the area of public policy formulation and decision-making. These include the shift towards evidence-based decision-making; the trend towards better governance and governance reform; and the adoption of sustainable development as the fundamental goal of public policy.

At the same time, it is acknowledged that the SIA approach to policy appraisal will inevitably need to be refined and adapted as experience in its application is accumulated.

2 ***Assessing the Impact of Trade Policy on Labour Markets and Production:***
   Joseph Francois, Tinbergen Institute and CEPR

Abstract. This paper discusses the measurement of production and employment effects of trade policy, and more broadly the effects of economic integration and globalisation. First, it provides a broad-brush overview of the ex-post literature linking trade to performance, such as measures of worker displacement, adjustment costs, and econometric evidence on trade and wages. It then defines structural impact indexes, illustrating their use with a stylised CGE model-based assessment of the impact of EU enlargement on the transition economies. Finally, the last section discusses the gap between our ex-post experience with adjustment costs, and what ex-ante methods actually tell us.

SESSION 2: ENVIRONMENTAL ISSUES

3. *Sustainable Impact Analysis: The Use of Computable General Equilibrium Models*

Christoph Böhringer, Centre for European Economic Research (ZEW), Mannheim

Abstract. This paper advocates computable general equilibrium (CGE) models as a methodological tool that is particularly suitable for assessing the impacts of policy interference on environmental quality, economic performance and equity. Recent developments in the field are presented that may further strengthen the role of CGE models in applied sustainable impact analysis. These developments include (i) decomposition procedures of general equilibrium effects that deliver a better understanding of key determinants for policy effects, (ii) the embedding of large-scale general equilibrium models in an optimal policy framework that considerably widens the scope of policy analysis, and (iii) systematic sensitivity analysis to test the robustness of model results with respect to uncertainties in the model's parameterization space.

4. *Impact of Trade Liberalisation on the Environmental Sustainability of Agriculture in the Countries Applicants to EU Accession:*

Luiza Toma, Katholieke Universiteit Leuven

Abstract. This paper analyses the linkages between the environment and agricultural trade, focusing on the case of the Central and Eastern European countries (CEECs), in the process of their accession to the European Union (EU).

The paper begins with a brief picture of the linkages between agricultural trade and environment. It then introduces state-of-the-art analysis as regarding trade and environmental distortions in the CEECs, and discusses the methodologies applied to assess the impact of agricultural trade on the environment, in the case of the accession countries.

5. *Building agri-environmental indicators by the integration of bio-physical and economic models for assessing sustainability of agricultural trade liberalisation:*

Guillermo Flichman, Agronomic Mediterranean Institute of Montpellier (IAMM)

Abstract. This article reviews the basic theoretical and practical issues concerning agro-environmental indicators, taking into account the specific characteristics of relations between agricultural production and environmental externalities.

The first section contains an overview of environmental indicators and agriculture. Agricultural activities have very complex relations with the environment and the natural resources (or natural capital).

The second section deals with some theoretical elements and empirical evidence of specific difficulties related to the analysis and measurement of agricultural externalities. These externalities frequently have discontinuous and non-convex relations with levels of production.

The third section presents the type of information ideally required to produce indicators of agro-environmental impacts arising from policy changes, in other words, the *state of the art*.

The fourth section deals with a specific proposal of what could be done in Europe in order to develop this field of applied research.

SESSION 3: SOCIAL ISSUES

6. ***Trade Liberalisation and Inequality Between Households. A Review of the Recent Empirical Evidence:***
   Pier Giorgio Ardeni, Universita di Bologna**.**

Abstract. There is a generalised consensus that inequality in the distribution of income in the last decades has increased both across and within countries. Explanations of such increases have mostly focused on effects of trade liberalisation and openness, on one hand, and of skill biases in labour markets, on the other hand, as the main culprit. This paper reviews that large part of the literature that sees globalisation and openness as the main responsible for the increase in inequality. It is observed that inequality across countries varies considerably when accounted for by GDP or household expenditure measures, and that the effects of globalisation on income distribution are not so clear-cut. Household expenditure data seem to provide a more detailed picture of inequality measures, which allows to identify separate components of inequality within country, across country and at the overall level. Micro-economic data do provide a more dis-aggregated picture, which enables to account for those distributive changes that previous studies at the aggregate level had not been able to disentangle.

7. ***Modelling the effects of trade on women, at work and at home: a comparative perspective:***
   Marzia Fontana, International Food Policy Research Institute, Washington, DC (IFPRI).

Abstract. The effects of trade on women vary by socio-economic characteristics, sector and country. This paper assesses how well such effects can be captured by a gendered social accounting matrix (SAM) and computable general equilibrium (CGE) model. The model covers not only all the sector of the market economy, but also household work and leisure, for women and men separately. It is applied comparatively to Bangladesh and Zambia to highlight how differences in resource endowments, labour market characteristics and socio-cultural norms shape the way in which trade expansion affects gender inequalities. The effects of tariff liberalisation appear to be more favourable in Bangladesh than in Zambia because of the higher female intensity of its export-oriented sector. The paper also compares simulation results to other approaches in the gender-and-economics literature, discusses strengths and limitations of the CGE methodology, and provides suggestions for further research.

ANNEX 3
LIST OF PARTICIPANTS

NAME	ORGANISATION
Pier Giorgio Ardeni	Universita di Bologna
Hanan Awwad	Friends of the Earth, Middle East
Ali Bayar	Free University of Brussels
Thomas Bernheim	Federal Planning Bureau
Christoph Boehringer	ZEW
Nicolas Boudeville	PricewatherhouseCoopers
Jean-Christophe Bureau	INAPG
Nicholas Aris Charalambides	European Commission
Sophie Chauvin	CEPII
Nicholas Christoforides	European Commission
Christine Dalby	European Commission
Tom Dedeurwaerdere	
Pierre Defraigne	European Commission
Neil Dourmashkin	Acacia Consulting
Guillermo Flichman	CIHEAM-Institut de Montpellier
Lionel Fontagné	CEPII
Marzia Fontana	IFPRI
Joseph Francois	Tinbergen Institute
Philippe Gautier	MEDEF
Jean-Baptiste Gros	ILO
Vladimir Hlasny	Michigan State University
Maros Ivanic	Purdue University
Marion Jansen	WTO
Mehran Kafaï	Planistat Luxembourg
Hubert Kieken	PricewatherhouseCoopers
Colin Kirpatrick	University of Manchester

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SUSTAINABILITY IMPACT ASSESSMENT METHODOLOGY: SIA STUDY OF PROPOSED WTO NEGOTIATIONS

Colin Kirkpatrick

SUMMARY

The development of a methodology for assessing the sustainability impact assessment of policy interventions is still at a formative stage, and the use of sustainability appraisal in decision-making has only begun to gain acceptance in recent years. Much of the early work on sustainability impact assessment (SIA) has focused on trade policy and has only recently begun to be extended to other policy areas.

The types of assessment methods used in trade-related appraisal studies are quite diverse, ranging between expert judgements, semi-quantitive local case studies and quantitative global systems modelling. This diversity in the assessment methods applied to trade measures is only partly explained by the formative nature of the subject. More fundamentally, it arises from differences in the purpose of assessments (ex ante or ex post, integrated or specialised etc); the nature of the trade measure being assessed (eg. changes in tariff barriers or rule changes; the breadth and diversity of the measure's constituent components; the geographical extent of its application); and the decision-making context in which the assessments will be used (for example, the range of stakeholders involved, the negotiating culture, and the stage(s) in the negotiating process at which the assessments are to be used).

The European Commission has been at the forefront of developing SIA, and in particular, in the application of SIA for the appraisal of international and regional trade policy initiatives. DG Trade is committed to undertaking a sustainability impact assessment of all major new trade negotiations, and SIA studies are currently being undertaken for the Doha Development Agenda, the MERCOSUR agreement, the EU-Chile trade agreement and the trade agreement between the EU and ACP states. More generally, sustainability impact assessment has been adopted by the Commission as part of its policy appraisal process, and from 2003, all major initiatives will be subjected to sustainability impact assessment, using new methodology guidelines.

The current interest in SIA within the European Commission, and more widely, can be explained in terms of the capacity of the SIA approach to address a number of key issues and concerns in the area of public policy formulation and decision-making. These include: the shift towards 'evidence-based' decision-making; the trend towards 'better' governance and governance reform; and the adoption of sustainable development as the overarching objective for public policy. In the case of SIA of trade policy, recognition of the need to 'act globally' has been a further motivation for the use of the sustainability impact assessment approach in decision- making.

This paper develops these themes in greater detail, with the objective of identifying the key requirements of a 'good' SIA methodology. There are three sections to the paper. Part 1 briefly reviews the existing methodology for SIA of trade negotiations, which began in 1999, and is currently being applied in carrying out a series of studies relating to the WTO-Doha Development Agenda. Part 2 considers a number of practical constraints and requirements, which need to be considered in the development of a SIA methodology. Part 3 will discuss the key trends in public policy and civil society whose convergence has led to the current interest in SIA and argue that the SIA methodology currently being used for the assessment of WTO trade negotiations addresses many of the requirements for a 'good' SIA methodology. At the same time it is recognised that the approach will inevitably need to be refined and adapted as experience in its application is accumulated. The final section provides a short summary and conclusion.

ABSTRACT

The Doha Ministerial Declaration confirms that sustainable development should be an overarching goal of WTO trade negotiations.

It also recognises that trade can promote economic development and alleviate poverty, and it places the needs and interests of developing countries at the forefront of the WTO work programme.

This paper describes a sustainability impact assessment (SIA) methodology for appraising the impact of trade policy measures on sustainable development, and argues that it addresses many of the current issues and concerns in the area of public policy formulation and decision-making. These include the shift towards evidence-based decision-making; the trend towards better governance and governance reform; and the adoption of sustainable development as the fundamental goal of public policy.

At the same time, it is acknowledged that the SIA approach to policy appraisal will inevitably need to be refined and adapted as experience in its application is accumulated.

JEL Classification: F13, F42, O19, O24

Key Words : Impact assessment; sustainable development; trade; developing countries.

MÉTHODOLOGIE DES ÉVALUATIONS D'IMPACT EN TERMES DE DURABILITÉ : EITD DES NÉGOCIATIONS PROGRAMMÉES À L'OMC

RÉSUMÉ

La mise au point d'une méthodologie pour évaluer l'impact en termes de durabilité des politiques est encore à un stade expérimental, et l'usage des expertises de durabilité comme préalable à la prise de décision a seulement commencé à être accepté dans les années récentes. La plupart des travaux menés jusqu'à présent concernant l'évaluation d'impact en termes de durabilité (EITD) a porté sur les politiques commerciales et n'a que récemment été élargi à d'autres domaines des politiques.

Les méthodes d'évaluation utilisées dans les expertises portant sur le commerce sont très variées, allant des jugements d'experts, aux études de cas locales semi-quantitatives et à la modélisation quantitative globale. Cette diversité dans les méthodes d'évaluation appliquées aux mesures commerciales ne s'explique qu'en partie par le caractère expérimental de la matière. Plus fondamentalement, elle provient des objectifs différents des évaluations (ex ante ou ex post, intégré ou spécialisé, etc.), de la nature de la mesure commerciale à évaluer (par exemple changements de barrières tarifaires ou de réglementations, ampleur et diversité des éléments constitutifs de la mesure, étendue géographique de son application) et du contexte décisionnel dans lequel les évaluations seront utilisées (par exemple le genre de parties prenantes impliquées, la culture de négociation, et le(s) stade(s) de négociation au(x)quel(s) les évaluations doivent être utilisées).

La Commission Européenne a été pionnière pour la mise au point des EITD, et en particulier pour l'application des EITD à l'expertise des initiatives de politique commerciale au niveau international et régional. La Direction Générale du Commerce s'engage à entreprendre une évaluation d'impact en termes de durabilité de toutes nouvelles négociations commerciales majeures et des études d'EITD sont à l'heure actuelle menées sur le plan d'action de Doha pour le développement, les accords avec le Mercosur, les accords commerciaux entre l'UE et le Chili ou encore entre l'UE et les pays du groupe ACP. Plus généralement, la Commission a inclu l'évaluation d'impact en termes de durabilité dans son processus d'expertise des politiques et à partir de 2003, toute initiative majeure sera soumise à une évaluation d'impact en termes de durabilité en suivant les nouvelles lignes directrices méthodologiques.

L'intérêt actuel porté à l'EITD à la Commission Européenne et ailleurs s'explique par la capacité de cette approche à aborder de nombreuses questions et préoccupations clés dans le domaine de la formulation des politiques publiques et de la prise de décisions. Il s'agit en particulier de baser davantage les prises de décisions sur la « réalité des faits », de tendre vers une « meilleure » gouvernance et une réforme de la gouvernance, et de faire du développement durable un objectif primordial des politiques publiques. Dans le cas de l'EITD des politiques commerciales, la reconnaissance de la nécessité d'agir à un niveau

global a constitué une motivation supplémentaire pour l'utilisation de l'évaluation d'impact en termes de durabilité dans les prises de décisions.

Cette étude traite ces thèmes de façon détaillée, son objectif étant d'identifier les principales conditions d'une «bonne » méthodologie d'EITD. L'article comporte trois parties. La partie 1 examine brièvement la méthodologie existante d'EITD des négociations commerciales, mise en œuvre depuis 1999 et actuellement appliquée pour effectuer une série d'études ayant trait au plan d'action de Doha pour le développement. La partie 2 passe en revue un certain nombre de contraintes pratiques et de conditions qui doivent être prises en compte pour développer une méthodologie d'EITD. La partie 3 traite des tendances clés des politiques publiques et de la société civile dont la convergence a conduit à l'intérêt actuel porté à l'EITD, et soutient que la méthodologie d'EITD utilisée à l'heure actuelle dans l'évaluation des négociations commerciales de l'OMC remplit la plupart des conditions nécessaires à une «bonne » méthodologie d'EITD. En même temps il est reconnu que cette approche devra inévitablement être perfectionnée et adaptée au fur et à mesure que l'expérience s'accumulera. La dernière partie fournit un court résumé et une conclusion.

RÉSUMÉ COURT

La déclaration ministérielle de Doha a confirmé que le développement durable devrait être un objectif primordial des négociations commerciales de l'OMC.

Elle a souligné également que le commerce peut favoriser le développement économique et réduire la pauvreté, et placé les besoins et intérêts des pays en développement au premier plan du programme de travail de l'OMC.

Cette étude présente une méthode d'évaluation d'impact en termes de durabilité (EITD) appliquée aux politiques commerciales et soutient que celle-ci répond à la plupart des préoccupations de formulation de politiques publiques et de prise de décisions. Il s'agit de baser davantage les prises de décisions sur les faits, de tendre vers une meilleure gouvernance, et de faire du développement durable l'objectif fondamental des politiques publiques.

En même temps il est reconnu que l'utilisation de l'EITD pour l'expertise des politiques devra inévitablement être perfectionnée et adaptée à mesure que l'expérience s'accumulera.

Classification JEL : F13, F42, O19, O24.

Mots-clefs : Evaluation d'impact ; développement durable ; commerce ; pays en développement.

SUSTAINABILITY IMPACT ASSESSMENT METHODOLOGY: SIA STUDY OF PROPOSED WTO NEGOTIATIONS[7]

Colin Kirkpatrick[8]

INTRODUCTION

The development of a methodology for assessing the sustainability impact assessment of policy interventions is still at a formative stage, and the use of sustainability appraisal in decision-making has only begun to gain acceptance in recent years. Much of the early work on sustainability impact assessment (SIA) has focused on trade policy and has only recently begun to be extended to other policy areas.

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The European Commission has been at the forefront of developing SIA, and in particular, in the application of SIA for the appraisal of international and regional trade policy initiatives. DG Trade is committed to undertaking a sustainability impact assessment of all major new trade negotiations, and SIA studies are currently being undertaken for the Doha Development Agenda, the MERCOSUR agreement, the EU-Chile trade agreement and the trade agreement between the EU and ACP states. More generally, sustainability impact assessment has been adopted by the Commission as part of its policy appraisal process, and from 2003, all major initiatives will be subjected to sustainability impact assessment, using new methodology guidelines.

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objective for public policy. In the case of SIA of trade policy, recognition of the need to 'act globally' has been a further motivation for the use of the sustainability impact assessment approach in decision-making.

This paper develops these themes in greater detail, with the objective of identifying the key requirements of a 'good' SIA methodology. There are three sections to the paper. Part 1 briefly reviews the existing methodology for SIA of trade negotiations, which began in 1999, and is currently being applied in carrying out a series of studies relating to the WTO-Doha Development Agenda. Part 2 considers a number of practical constraints and requirements, which need to be considered in the development of a SIA methodology. Part 3 will discuss the key trends in public policy and civil society whose convergence has led to the current interest in SIA and argue that the SIA methodology currently being used for the assessment of WTO trade negotiations addresses many of the requirements for a 'good' SIA methodology. At the same time it is recognised that the approach will inevitably need to be refined and adapted as experience in its application is accumulated. The final section provides a short summary and conclusion.

1. THE SIA STUDY OF WTO TRADE NEGOTIATIONS

1.1. A definition of Sustainability Impact Assessment (SIA)

For the purposes of the SIA-Trade studies, SIA is defined as a methodology for assessing the impact of a trade policy change on sustainable development. The assessment will usually be ex ante (potential impact) but could include ex post (actual impact) evaluations as part of the process. Sustainable development is taken to incorporate economic, environmental and social development.

SIA is both a *method* and a *process* for assessment. As a method, it systematically and consistently examines economic, environmental and social impacts arising from a policy intervention; includes both negative and positive impacts; and indicating the likelihood and scale of the impacts. As a process, SIA adheres to the principles of transparency, accountability, and consultation and participation.

1.2. The EC's SIA of WTO trade negotiations

The EU began its SIA studies of WTO trade negotiations in 1999. The Institute for Development Policy and Management at the University of Manchester was contracted to develop a SIA methodology (Phase I) and to undertake a preliminary assessment of the Seattle agenda (Phase II) prior to the Seattle Ministerial Meeting in Seattle in late 1999. In 2001 a further study was completed which developed the Phase I Methodology. This extended methodology is currently being applied to the Doha Development Agenda (Phase III), where the objective is "to provide an analysis of the sustainability impacts of agreed policy options or scenarios, and to present this analysis in such a way as to give a concrete input for negotiators in their search for a balanced set of policies, including any necessary flanking measures."

Phase III, which will continue over several years, will consist of a preliminary global SIA (all sectors); a series of detailed sector studies; and a global SIA of provisional agreements. The first year of Phase III (April 2002-March 2003) involves the preliminary global overview study, and detailed sector studies for market access (pharmaceuticals, non-ferrous metals, textiles); environmental services (water and waste treatment); and competition policy.

The Phase I, II and III reports are available on the project website: http://idpm.man.ac.uk/sia-trade.

1.3. The main stages in the SIA process

This section describes the main stages in the SIA methodology proposed by the contractors for use in Phase III.

The main stages in the SIA process are:

- Stage 1 : Screening and scoping.
- Stage 2 : Detailed assessment of proposed measures
- Stage 3 : Assessment of alternative mitigation and enhancing measures (ie, optional analysis)
- Stage 4 : Monitoring and post-evaluation proposals.

STAGE 1: SCREENING AND SCOPING

The fundamental purpose of these scoping studies is to systematise the determination of the terms of reference for the SIA of each measure, which is to be assessed. This will involve determining:

The specifics of each trade measure to be negotiated (and of those of its components) which should be submitted to detailed assessment at the next stage in the process. Different types of measures (e.g. tariff reductions, rule changes) may need to be assessed in somewhat different ways.

The specific scenarios (i.e. potential negotiation outcomes) for each measure/component, which should be analysed in the detailed assessment.

The criteria by which the significance of the sustainability impacts is to be assessed.

The country groups and/or individual countries for which the sustainability impacts should be assessed.

The time horizons over which the impacts should be assessed.

The cumulative impacts, likely to result from the implementation of the New Round as a whole, which should be assessed.

The methods, data sources and sustainability indicators to be used, and the consultations to be undertaken, in the detailed assessments and in subsequent stages in the assessment process.

Scoping is expected to involve simplified forms of causal chain analysis (CCA) which help in identifying the potentially important sections of each causal chain which link, in sequence, each trade measure to its eventual, significant impacts. Scoping should also include a preliminary identification of the types of M and E measures that might need to be appraised later in the SIA process, classified according to the individual trade measure scenarios to which they relate, and for the Round as a whole.

STAGE 2: DETAILED ASSESSMENT

Causal chain analysis is used to trace, both analytically and empirically, the main causal links between each trade measure, its main components and their eventual sustainability impacts. A number of the core sustainability indicators may be subdivided into 'second-tier' indicators. Additionally, in order to capture some potentially important long-term sustainability impacts, a limited number of SIA process indicators may also be used. The impact significance categories and their boundaries need to be defined explicitly and supporting evidence, for the significance 'scores' obtained, will be required.

Detailed assessments will attempt to capture the more important variations in significant impacts within country groupings. This can be done by extending the sustainability analysis to selected, contrasting countries within each major country group being studied, and examining likely major variations within these, according to region and/or socio-economic category.

The main findings of the detailed assessments can be presented at different levels of aggregation – for example, for individual components of a trade measure as well as for the trade measure as a whole; for different scenarios; for contrasting countries as well as for country groups as a whole. These need to be supported by both a textual explanation and an evidence-based justification for the principal findings they contain.

STAGE 3: ASSESSMENT OF ALTERNATIVE MITIGATION AND ENHANCING MEASURES

Given the importance which the Doha Ministerial Declaration attached to the needs and interests of developing countries, and in particular to the vulnerability of the least developed countries, public discussion has focused on the assessment of M and E measures which might be used to mitigate and enhance the impact of trade measures on sustainable development in the developing and least developed countries.

The overall coverage of the measures considered for inclusion, is broadly defined to include:

- Measures which are closely trade-related and which might be built into a WTO agreement itself.

- Closely related side or parallel agreements between WTO member countries, or in regional agreements which may 'nest' within international agreements.

- Collaborative agreements and other joint initiatives between international organisations to clarify the relationship and strengthen the consistency, between international trade agreements and other types of international agreements.

- International and regional initiatives to promote technical cooperation and capacity building in developing countries.

- Measures by national governments to remedy market imperfections, regulationary failures, social inequalities, which are harmful to sustainable development and whose removal could enhance the contribution which trade measures may make to sustainable development.

The range and types of M and E measures that have been identified need to be assessed as the third main stage in the process for full SIA assessment.

The findings of each sectoral assessment, in terms of the end-impacts on sustainable development, should be examined using the detailed causal chain analyses that were developed at stage 2 (detailed assessment), in order to identify where the introduction of M and E measures could have a significant benefit. The most promising M and E options should then be separately appraised for their potential sustainability impact. Criteria for assessing M and E measures should include:

- impact on sustainable development: the likely economic, social and environmental consequences of the M and E measures, assessed in terms of either the core or second-tier target indicators, and process indicators, proposed for Phase Three ;

- cost-effectiveness: the size, type and distribution of costs associated with the implementation of the M and E measures ;

- feasibility: the capacity of political, institutional and financial processes for effective implementation of the M and E measures.

The application of these assessment criteria should identify a set of 'best' M and E measures that are cost-effective, feasible and likely to have a significant effect in terms of mitigating the negative sustainability impacts and/or enhancing the positive sustainability impacts, that were identified at the detailed assessment stage.

The assessment of the impact of the 'best' M and E measures on the core economic, social and environmental indicators should then be introduced into the detailed assessment findings, as a modified scenario for the relevant trade measure.

STAGE 4: MONITORING AND POST EVALUATION PROPOSALS

There is growing interest and concern, both in the assessment field, generally and in the trade policy assessment field, in particular, that *ex ante* appraisals of proposed new measures should be complemented by an *ex post* evaluation of those same measures after they have been approved and implemented.

Provision for monitoring and evaluating the sustainability impacts of the New Trade Round Agreement, as finally approved, should be considered, therefore, as a potentially important mitigation and enhancing measure for inclusion in the final agreement on the New Round.

The MPE proposal should contain a number of components. These should include provision for:

- Monitoring the implementation of the provisions of the New Round agreement itself (This should draw upon the assistance of the WTO).

- Monitoring and undertaking an *ex post* evaluation of the sustainability impacts of the New Round agreement, as implemented.

- Post-evaluation of the *ex ante* Phase Three SIA studies i.e. comparing their predictions with actual outcomes and explaining any significant differences between them.

- Making recommendations relating to: any implementation problems which have been encountered; additional M and E measures which may be needed to address any significant, unanticipated or unresolved sustainability impacts; strengthening existing *ex ante* and *ex post* SIA methodologies and their use in practice.

There is a substantial, increasing general literature on monitoring and evaluating the implementation of sustainable development strategies, as well as a more specialised literature on the evaluation of the economic, social and environmental impacts of previously adopted trade agreements. Based upon this literature, and the practical experience on which it draws, a number of preliminary suggestions may be made:

- Monitoring and evaluation should engage the interest and commitment of the key stakeholders, in international and national administrations, and within civil society. Particular attention should be paid to the involvement of stakeholders from developing countries.

- Monitoring and evaluation should be both clearly focused and strategic in nature, and avoid the collection and analysis of less important and unnecessarily detailed information.

- Monitoring and evaluation should be sufficiently independent and transparent to ensure the objectivity and credibility of its findings. The findings, including recommendations for improvements, should be published at agreed, regular intervals and be subject to consultation and comment.

2. SOME 'FITNESS FOR PURPOSE' CONSIDERATIONS IN THE DEVELOPMENT OF THE SIA METHODOLOGY

The SIA methodology needs to provide an analysis of the sustainability impacts of various policy options or scenarios in a way that is accessible to policy makers and will contribute to the negotiation process. It should also have other, wider uses. These include the use, and if necessary adaptation, of the methodology by other users to carry out their own assessment of the likely sustainability impacts of trade policy proposals.

The methodology also needs to be adaptable to meet the SIA requirements at the different stages in the negotiating process in which the resultant assessments are to be used. In addition, it needs to take account of the real world constraints within which the particular assessment will be prepared. These constraints include: the limited availability of appropriate 'on the shelf' assessment tools; limited availability of appropriate and reliable data for use with these tools; and limitations in time and resources for delivering assessments within the schedules of the trade negotiation process.

The SIA methodology should be sufficiently feasible to allow for different levels of detail, while retaining a comprehensive and strategic level focus of analysis. Given their global scope, SIAs of international trade agreements will inevitably be more 'strategic' than 'specific' in character and relatively small increases in the level of detail and precision in such assessments can, depending on the circumstances of the particular case, substantially increase their technical data and/or resource requirements. No general rules exist on the 'best' level of detail for assessments. This can only be determined and justified on a case-by-case basis, which should be separately established as part of the 'screening and scoping' stage of the SIA methodology (see above).

Consultation is an integral part of the SIA process, and provides a means by which stakeholders can contribute to the assessment, both as experts and as interested parties. The form and procedures for consultation and participation in the SIA process will also vary on a case-by-case basis, and will need to be determined at the beginning of the SIA.

Each study will need to bring together, therefore, a number of different components (figure 1):

SIA method

- The assessment tasks to be undertaken

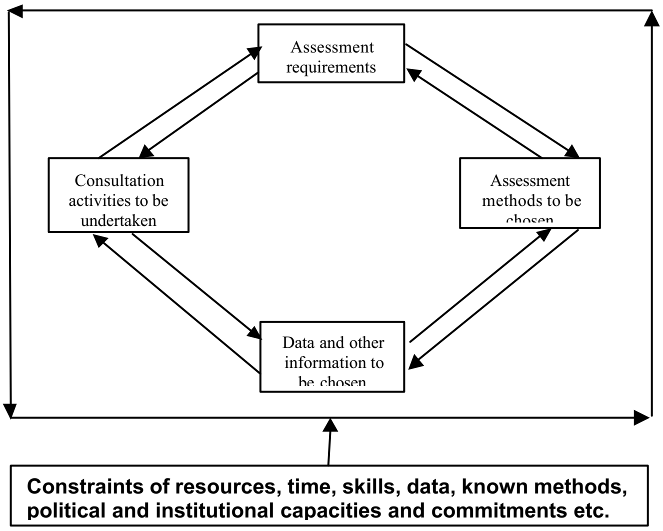
- The assessment methods required to undertake these tasks

- The data needed to apply the assessment methods and the sources from which the data may be obtained

SIA process

- Consultation activities to be undertaken.

Figure 1 : The assessment methodology cycle



Each of these four components has to be consistent with others. For example, if there is sufficient data available, the choice of assessment methods may need to be modified and the assessment requirements may need to be more modestly defined. Also, the specification of all of the components within the assessment method cycle is constrained by the resources, skills, methods, data and institutional capacities and commitments which exist. The more restrictive these are, the more modest will be the practical assessment methodology which can be chosen. It follows, therefore, that the methodology approach – the preferred combination of requirements, methods, data and consultations – is likely to be case-specific, and will need to be clarified in the specification of the approach to be used for each policy measure which is to be assessed.

The scheduling of the SIA process for each trade measure should ideally correlate with the scheduling of its negotiation. The SIA process should commence sufficiently early to enable the sustainability appraisal itself, and the consultations based upon it, to be completed in sufficient time for negotiators to take them fully into account before any agreement is reached and later approved.

Additionally, the scheduling of each SIA study should be correlated with arrangements for consultations relating to the SIA. The synchronisation of key stages in the SIA process (including accompanying arrangements for consultant with key stages in the negotiation process is the ideal, but in practice will probably be difficult to realise fully.

3. The contribution of SIA to good governance

3.1. SIA and 'evidence-based' policy analysis

The credibility of policy proposals with decision-makers and with stakeholders, is strengthened if the proposal is based on an 'objective' analysis of the potential benefits and costs that would ensue from its adoption. SIA as a method of analysis, provides a framework for the assessment of the potential impacts on sustainable development.

The Communication from the European Commission on Impact Assessment was published in June 2002. Here the Commission announces its intention to launch impact assessment as a tool to improve the quality and coherence of the policy development process. Gradually, from 2003, all major initiatives will be subjected to the new impact assessment method which will replace all existing impact assessment arrangements by building on them and implementing them into the new tool.

The impact assessment procedure will consist of a preliminary assessment giving an overview of the problem identified, possible options and sectors affected and an indication of whether an extended assessment is needed. An extended impact assessment will carry out a more in-depth analysis of potential economic, social and environmental impacts and will consult with interested parties and relevant experts according to the minimum standards for consultation following the guidelines given in the Communication on Consultation.

The role of SIA in providing a methodological framework for evidence-based ex-ante policy analysis has been highlighted in the post-Doha trade arena. If the Doha Work Programme is to be successful, the WTO-led process of discussion and negotiation will have to demonstrate that the lessons of Seattle have not just been incorporated into the WTO's rhetoric, but are being effectively translated into practice.

The driving force behind the prominence given to the development dimension in the Doha Agenda was the developing countries' concern about the implementation of the results of the Uruguay Round. Implementation-related issues included: the limited gains to developing countries from the Uruguay Round; the backloading of liberalisation in textiles and clothing; the use of special safeguards; anti-dumping measures; more restrictive rules of origin to limit potential benefits from tariff liberalisation; and the limited progress in liberalising trade in agriculture. Developing countries also argued that a number of commitments to take special account of their needs, for example, in the Anti-Dumping Agreement, had no legal force and were not applied in practice. A further concern related to the difficulties and costs to the developing countries in participating fully in the WTO, and in meeting their obligations under the WTO Agreements.

The Doha Ministerial Declaration recognised the implementation-related issues and concerns of developing countries: “We attach the utmost importance to the implementation-related issues and concerns raised by Members and are determined to find appropriate solutions to them….. We agree that negotiations on outstanding implementation issues shall be an integral part of the Work Programme….” (para. 12.).

One lesson to be learnt from the implementation issue is the need for negotiators to be better informed on the likely outcome of adopting a particular market access or rules measure. It will no longer be sufficient to rely on the general presumption that trade liberalisation will always produce a ‘win-win’ outcome for all parties. This highlights the need in any future negotiations to carry out detailed assessment of the costs, and benefits of market access and rules commitments. This assessment needs to be ex ante, undertaken prior to the negotiation stage, thereby serving to inform negotiators of the potential impact of any proposed measure for inclusion in a new round of trade negotiations.

To be credible with policymakers, the assessment of trade measures needs to be well grounded in analysis and fact, demonstrating an understanding of the processes that are taking place (what we have referred to as causal chain analysis). A key issue is the terms in which the assessment will be conducted. Logically, this will be set by the objective, or goal, of the policy being considered. Traditionally, the goal of multilateral trade liberalisation has been defined in terms of economic welfare, which has set the yardstick or numeraire, for assessment of impact in economic terms. Economic analysis of trade measures is, therefore, the most obvious and easily provided form of policy analysis. One of the defining features, however, of the Doha Declaration is the commitment to the goal of sustainable development. Thus, while economic analysis is likely to provide the initial, or ‘first round’ assessment of impact, it will need to be complemented by assessment of environmental and social/poverty impacts.

Methodologies for environmental and social/poverty impact assessment at the strategic, or policy level, are less well developed then for economic assessment. Environmental impact assessment (EIA) was originally designed and applied at the project level, and it is only comparatively recently that the methodology for strategic environmental assessment (SEA) has been developed. Application of SEA to trade policy analysis has proceeded mainly by the use of descriptive, case study methods. These are largely empirical in nature and make use of both quantitative and qualitative data. In most cases they are ex post assessments. A difficulty with this approach is that the methodology may be insufficiently developed, and the causal links between the trade measure and its eventual environmental outcome may be inadequately explained. There are however, an increasing number of studies which have addressed these difficulties, and have refined the practical use of environmental assessment methods applied to trade policy.

There has been comparatively little detailed assessment of the social/poverty impact of trade policy measures. In part, this reflects the methodological difficulties in establishing the causal chain between a particular trade measure, and its impact on poverty at the disaggregated individual household or community level.

In summary, ex ante assessment of the Doha Agenda is a necessary part of the process of ensuring that the Agenda moves forward, from agreement in principle to implementation in practice. This assessment needs to incorporate the WTO's commitment to the goal of sustainable development, by allowing for the potential economic, social and environmental impacts of any proposed trade measure.

In assembling the information and evidence base for the assessment of impacts, the IDPM-SIA methodology proposes the use of Causal Chain Analysis (CCA).

The fundamental purpose of causal chain analysis (CCA) is to identify the significant cause-effect links between a proposed change in an existing trade agreement and its eventual economic, environmental and social impacts (i.e. its impacts on sustainable development). CCA can be used at different levels of aggregation and detail, depending on the context and requirements of the situation. It can also be used at different stages in the SIA process. The aim of CCA is to distinguish the *significant* cause-effect links in the chain. Significance criteria have to be formulated and then used to eliminate non-significant sections and terminate further analysis beyond these sections. The analysis is usually undertaken, in logical sequence by section, from 'cause' to 'effect'. However, a useful crosscheck can be undertaken by reversing the analysis (i.e. sequentially, by section, from 'effect' to 'cause') to ensure that the projected SD impacts are sufficiently 'explained' by the trade agreement change. Both the causal chain analysis itself, and the causal chain analysis findings, may be presented in the form of a causal chain diagram (sometimes called a cause-effect diagram). This shows each of the cause-effect sections which have been investigated (plus some sub-sections, in more detailed diagrams) in their logical order of causality, distinguishing those that are significant from those that are not.

The CCA will be supported by other, more specialised assessment tools for analysing, modelling, predicting cause-effect links in the chain.

A wide range of assessment methods exist which might be used in the elaboration of causal chains and in the empirical estimation of sustainability impacts. These include: modelling methods, data-based (statistical estimation) methods, descriptive (case study) methods, expert opinions and consultation methods.

Surveys of these different methods, examples of their application to trade policies and supporting literature reviews confirm that there is no single type of method which can currently satisfactorily meet all of the assessment requirements for SIAs of trade agreements. A package of methods is most likely to be required, where each package varies to some degree, according to the characteristics of the trade measure(s) being assessed and the context (e.g. regional and country characteristics) in which the assessment is being carried out. The strengths, limitations and possible applications of the main types of methods which might be included in an SIA methods package, are briefly reviewed:

<u>Modelling methods.</u> Models are simplified, structured representations of systems. Each has its own analytic structure and to this extent it shares the same strengths and weaknesses as the analytic methods described above. Some models are essentially theoretical.

However, most of the trade-related models, are empirical in the sense that they use data (mainly in a quantitative form) and predict likely future impact outcomes, or explain previously observed impact outcomes, based on these. Whilst this might suggest that models are superior to analytic methods, this depends on the relevance and quality of both the modelling and the data which are used.

Examination of the relative merits of different types of models for use in SIA studies leads to the following conclusions:

i. There is no single modelling system currently in being which satisfactorily assesses economic, social *and* environmental impacts likely to result from changes in specified international trade policies. Most existing models are still confined to elements of that system. They are mainly limited to the trade-economy sectors, but some extend to include parts of the environmental or social sectors.

ii. Most models have been developed to assess impacts resulting from price changes due to trade liberalisation. Much less attention has been paid to how, and how far, the impacts of changes to trade rules and other kinds of trade measures may be satisfactorily assessed, using modelling methods.

iii. Because of the complexity of the systems involved, and known limitations in data availability, existing models (though appearing to the layman to be very complex) are greatly simplified to make them operational. Therefore, it is important to check the underlying logic of the model itself (i.e. its assumed cause-effect links) and the assumed values (coefficients) of those linkages.

<u>Data based (statistical estimation) methods</u>. These use time series and/or cross-sectional data to test for possible causal links within a trade-sustainable development framework. In particular, they test for a statistically significant relationship between specified parameters of a proposed trade measure and changes in the values of one or more of the selected SD indicators and/or (at a more detailed level) between cause and effect variables on particular sections of the causal chain.

A potential advantage of these types of methods is that they provide opportunities to test, empirically, specific hypotheses (preferably, which have sound theoretical formulations) about the nature of cause-effect links within a trade-sustainable framework and to establish their statistical significance. Further, if the data used has been carefully collected from a sufficiently large and representative sample (e.g. from individuals, households etc.), the results may be generalised to different geographic and socio-economic aggregates (village, region, country, women, minority groups etc.). The findings may then be valuable in their own right within SIA studies or may be used in conjunction with other assessment methods – for example, in specifying functional coefficients within SIA trade models, in enriching descriptive case studies and/or in assisting to make expert judgements.

Like all other assessment methods, they also have their drawbacks and limitations. They generally have a more limited role to play in assessing cause-effect changes where these are of a more qualitative nature. This is part of a more general problem that qualitative changes within the SIA framework tend to get neglected or be treated inadequately (as is also the case in a number of modelling studies). Many statistical estimation studies use time series data which produce estimates of coefficients etc. which may be historically correct but not necessarily appropriate to future conditions. Because of practical difficulties (lack of certain types of data etc.) the hypotheses which are tested may implicitly over-simplify the causal chain (e.g. by excluding some of its intermediate cause-effect links) leading, over time, to incomplete explanations of change and increasingly inaccurate assessments due to the growing influence of excluded variables.

Further, as in all empirical studies, much depends upon the quality of the data which are collected and used. As in the case of modelling studies, there is always some risk that greater attention will be given to the appropriate application of the statistical technique than the appropriateness and quality of the information which it assembles and processes. However, it must also be recognised that gathering new data, of the types and quality required for SIA studies, is likely to be an expensive and time consuming exercise.

Studies, based on the use of statistical estimation methods, should make a useful contribution to SIA studies, though in many cases this will be supplementary to the contributions from other assessment methods. As with modelling studies, it is important that, in each case where these methods are used, the statistical estimates themselves and the quality of data employed are evaluated. It is assumed that most use will be made of *existing* statistical estimation studies. Some selective *new* applications of existing statistical estimation methods, which use *existing*, readily accessible data, may be undertaken. New data gathering for use with these methods is unlikely to be feasible, given time and other constraints.

Descriptive (case study) methods. This group of methods is less well-defined than the other types of methods reviewed in this section and is probably the most heterogeneous. In most cases, these methods are mainly empirical in nature and make use of both quantitative and qualitative data. They tend to focus upon a particular sector (e.g. mining, fishing); a national, regional or local community; and/or a particular socio-economic group (especially disadvantaged groups). In most cases they contain *ex post* assessments; relatively few systematically examine the likely future effects of proposed new agreements.

These types of studies are potentially useful to SIAs in a number of ways. They often consider different types of questions, at less aggregated levels of assessment, using different methods of investigation to those mainly used in modelling and statistical estimation. At their best, they can show a deeper understanding of the ways in which internationally-agreed trade measures may have greatly varying sustainability impacts.

A difficulty with a number of descriptive studies is that their methodology is insufficiently developed or explained. Several studies make relatively simple 'before-and-after' impact comparisons. For the most part they do not sufficiently examine the causal chains which link the trade measure to its eventual economic, environmental and social outcomes. Also, they often ignore the counter-factual question and fail to take account of the additional impacts that would have occurred even if the new measure had not been introduced. Additionally, there are sometimes uncertainties (as in other studies) over precisely what data have been used, their levels of reliability and how they have been analysed and interpreted in reaching conclusions.

However, there is an increasing number of empirically based, more disaggregated studies being produced which address a number of these difficulties. Some, for example, carefully use inductive methods for investigation, which are rooted in an explicit, well-defined methodology, to develop a rich understanding of cause-effect relationships, and assemble different kinds of good quality information to assess trade policy impacts on local communities, disadvantaged groups etc. Others use a combination of descriptive cause-effect analysis (possibly then formalised in a simple model) and some statistical estimation analyses to provide a combined quantitative and qualitative analysis of trade impacts on a local or regional area. Additionally, there have been a number of regulatory-based impact studies using somewhat different forms of juridical and organisational analysis, which have contributed to the impact assessment of rule changes within international trade agreements.

It is recommended that selective use be made of descriptive methods of impact assessment within SIA studies. They could be particularly helpful in understanding the variations in impacts at more disaggregated levels – sector, area and socio-economic group – and especially, where more qualitative assessments are appropriate. A focus on assessments within particular countries should assist in screening and scoping the existing descriptive studies to be submitted to more detailed analysis. They should be individually evaluated for their quality and relevance before final acceptance. Some assistance from local experts may be needed in the evaluation and interpretation of their findings. Due to resource and time limitations it is unlikely that a programme of new descriptive studies could be undertaken but more limited arrangements for some gap-filling may be feasible, with the aid of local experts.

<u>Expert opinion</u>. From time to time, surveys are undertaken of the range of assessment methods in existence, and of the frequency with which each is used in practice. Among those methods which appear on an ever-lengthening list, it is the least formalised and sophisticated – expert opinion – which is often the most frequently used, though possibly the least publicised. Therefore, some reference should be made to its potential role in Phase Three studies. It is likely to be important in SIA studies for the following reasons:

- There is no standard SIA methodology which is applicable in all circumstances. It has to be ‘tailor-made’ for, and ‘case specific’ to, each assessment situation. Expert opinion will need to play a significant role in the development of the ‘case specific’ methodology, through the screening and scoping updates and consultation based on these.

- There is no comprehensive SIA methodology in being which is yet fully operational. It has to be welded together from a number of different parts – which are trade, economic, environmental and society-related. Expert opinion, with other forms of supporting assistance, will need to play a central role in making this fusion work.

- There are many gaps in method, knowledge and data within the components which will form the comprehensive SIA methodology. This is not surprising in a new and innovative field of assessment. Only to a limited degree, can these gaps be filled through additional research, data gathering and new empirical studies over the lifetime of the Phase Three studies. In most cases, the 'second-best' solution will lie in using expert opinion, to make most effective use of the methods, knowledge and data already available.

Where expert opinions are used, it is important that the evidence and analysis upon which they are based are made explicit. In other words, they should be substantiated and justified.

Different types of experts should be employed on SIA studies and play differing roles within them. They include:

- Core team experts who will be involved in overseeing the development and successful application of all of the methodologies to be used in Phase Three studies. Between them, they should possess sufficient skills and knowledge relating to the main methods to be used and have the capacity to integrate them successfully within a single unified methodology.

- Sector experts who should possess skills and knowledge appropriate to the particular sectoral assessments in which they will be involved.

- Region/country experts who possess assessment skills and knowledge appropriate to the regional or country context in which part of an SIA study is to be conducted.

- Other external experts who belong to the international network of SIA experts who may be consulted about the specifics of a particular case, or methodological and data issues.

- Other consultees (e.g. stakeholder organisations, NGOs) who may be asked for their opinions on matters contained in screening and scoping updates and later full assessments or may be asked for opinions and advice on specific issues arising during the assessment process.

<u>Data constraints</u>, in terms of quality and availability, will partly determine the practical assessment methodology which can be chosen, and the level of detail at which it can be applied. The data constraints are likely to be case-specific, and are likely to arise in a number of different forms. They include:

- the definition used for the collection and measurement of data may diverge from the ideal definition required for sustainability assessment purposes. For example, the 'ideal' measurement of real income includes the social and environment costs and benefits of economic activity, whereas the actual measure of real income (at the national level) does not allow for these externalities.

- the data gathered may diverge from the measurement definition. There may be differences in accounting and estimation procedures between countries, which make cross-country comparisons difficult. A lack of comparability in price and exchange rate information, for example, makes cross-country comparisons of real output levels and growth rates difficult.

- some data may be unavailable, or inaccessible for reasons of confidentiality. In these cases, the 'missing' data may have to be estimated or extrapolated on the basis of historical data or expert opinion.

- different sources of data relating to the same indicator may be incompatible or difficult to use in combination. For example, data on real income which is gathered from household survey sources may not be easily reconciled with national accounting statistics on aggregate household real income. Different sources of data may be better suited to particular assessment methods, for example, trade modelling will normally use national accounting statistics, whereas case studies will rely more on household-level data. If there are difficulties in reconciling and combining different data sources, it may limit the ability to make use of the range of assessment methods, at the screening and scoping update and full assessment stages.

The data constraints mean that the available data will typically be an *approximation* of the ideal data requirements for sustainability impact assessment. In judging the suitability of data for use in sustainability impact assessment, it is recommended that the data requirements be defined as precisely as possible. The available empirical data that approximates this definition should then be identified. Finally, the degree of discrepancy between the definition and the empirical data should be assessed and a judgement made on whether the data is to be used in the assessment. Where the data is used, any significant discrepancies or limitations should be recorded at the screening and scoping stage, and acknowledged in the presentation and interpretation of the assessment results.

The EC Communication on Impact Assessment discusses the use of quantitative and qualitative impact data and states "Where it is not possible to assemble all relevant data within a reasonable time frame, qualitative or partial data will be used". This could be interpreted as suggesting that qualitative data will be used only when insufficient quantitative data is available. This would be regarded by many practitioners of impact assessment as a mistake. The consensus among researchers has been for some time now that a judicious mix of quantitative and qualitative methods is usually required. Both have strengths and weaknesses and can be creatively used to complement each other.

Qualitative research methods e.g. semi-structured interviews, focus groups, participatory appraisal methods, are essential for developing an accurate as possible picture of competing hypothetical realities – the core function of SIA. To understand complex realities where people's values, perceptions and judgements will affect their response to policy and therefore affect policy impact requires going beyond a purely quantitative picture of reality.

To investigate hypothetical impacts of proposed policy change and establish causal chains, which turn out to have credibility in terms of accurate prediction i.e., are supported by impact analysis at the ex-ante stage, requires methods which go beyond the strictly quantitative. In order to answer questions as to *what* impacts will occur SIA has to find some answers to *how* and *why* they occur.

3.2. Participation and consultation

The EC's Communication on Impact Assessment (June 2002) states "Impact assessment is an aid to decision-making, not a substitute for political judgement. Indeed political judgement involves complex considerations that go far beyond the anticipated impacts of a proposal". Two pages later it states that "The aim of the impact assessment process is that the Commission bases its decisions on sound analysis of the potential impact on society".

Participation imposes costs, and participants need to have confidence that the time, effort and expense involved are worthwhile. Potential participants have a fundamental choice as to whether or not they participate in any given consultative process. Indeed one of the current problems in governance, particularly for international organisations, is the large number of NGOs and activists who have declined to take part in consultation and instead chosen to operate from outside the conference room. These include people with sophisticated analyses who have come to the conclusion that much consultation is "greenwash". Consultation undertaken for cosmetic purposes can only undermine genuine efforts to contribute to good governance.

The Communication on Impact Assessment identifies those policy proposals which will qualify for impact assessment. It also states "However, certain types of proposal will normally be exempt from the impact assessment procedure. This would include proposals like Green Papers where the policy formulation is still in process". What is of concern here is the implication that it is only those proposals where policy formulation is *not* still in progress that are suitable for impact assessment.

If impact assessments cannot affect the formulation of policy it is difficult to see how to justify the considerable effort of carrying them out. At a later stage in the document it is stated that "as to the policy choice, the final options will emerge through the impact assessment process" (page 9) thus indicating that indeed impact assessments are expected to contribute to policy formulation as one would expect. Do these two examples of apparently inconsistent statements reflect a lingering ambiguity in the Commission's approach to public participation in policymaking?

3.3. The contribution of SIA to good governance – the example of the EU

The European Commission identified the reform of European governance as one of its four strategic objectives in early 2000. In its White Paper on European Governance it noted that "many people are losing confidence in a poorly understood and complex system to deliver policies that they want". The White Paper proposes "opening up the policy-making process to get more people and organisations involved in shaping and delivering EU policy".

Identifying openness, participation, accountability, effectiveness and coherence as the five principles underpinning good governance the Commission recognises that the very legitimacy of the EU depends on involvement and participation.

The White Paper also discusses how the EU should apply the principles of good governance to its global responsibility, including aiming to improve the effectiveness and legitimacy of global rule-making and helping to complement international action with new tools.

One outcome of the White Paper has been the publication of a proposal for general principles and minimum standards for consultation of interested parties by the Commission. Another significant outcome was the Mandelkern Group's Report on Better Regulation published in November 2001. This emphasised the need to address the whole life cycle of policy (inception, design, legislation, implementation and review) and its recommendations included embedding a new, comprehensive and suitably resourced impact assessment system as an integral part of the policy making process. The report also stressed the importance of consultation and identified one of the potential benefits of impact assessment as the framework for such stakeholder involvement which it can provide.

Sustainable impact assessment (SIA) can provide a bridge between current practices in policymaking and the sort of visionary aim expressed by the European Commission in its White Paper on European Governance:

"… the linear model of dispensing policies from above must be replaced by a virtuous circle, based on feedback, networks and involvement from policy creation to implementation at all levels". (page 11)

The underlying philosophy of, and best practice in, SIA relates to these and other aspirations of the White Paper. Here SIA is defined simply as the process of identifying, and assessing the likelihood and scale of, the economic, social and environmental impacts of any policy change whether positive or negative. Such a process clearly requires the active participation of a wide group of stakeholders. And the purpose of it is to ensure that those charged with making policy have the best and most complete information possible to guide them in their decision-making.

The EU's approach to better governance has recently led to a decision to implement SIA for all policy proposals of a certain level of significance.

Sustainable development

Two months prior to publishing its White Paper on European Governance the Commission published its proposal for "A sustainable Europe for a better world: a European Union strategy for sustainable development". The Commission identifies the Brundtland Commission's definition of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" to be a global objective and states that, in the long term "economic growth, social cohesion and environmental protection must go hand in hand".

The Commission considers that its sustainable development strategy should be "a catalyst for policymakers and public opinion in the coming years and become a driving force for institutional reform and for changes in corporate and consumer behaviour". A new approach to policymaking is identified as requiring urgent action. Although many EU policies address the economic, social and environmental dimensions of sustainability "these have developed without enough coordination. Too often, action to achieve objectives in one policy area hinders progress in another".

Therefore assessments of policy proposals must include estimates of their economic, environmental and social impacts inside and outside the EU. "It is particularly important to identify clearly the groups who bear the burden of change, so that policymakers can judge the need for measures to help these groups to adapt". And, recognising that EU policies have consequences far beyond its geographical borders, "policies must actively support efforts by other countries – particularly those in the developing world – to achieve development that is more sustainable".

CONCLUSION

This paper has described a methodology for the sustainability impact assessment of trade policy measures, which aims to achieve a balanced coverage of economic, social and environmental impacts (both positive and negative), and at the same time, to be practical, accessible to decision-makers, transparent to stakeholders, and participatory in its approach. In so doing, it addresses current concerns for evidence-based policy formulation and for broader reforms in governance processes. Thus, while the approach may be judged and lack technical sophistication, it is considered appropriate to the task and the circumstances in which it can be used.

The current phase of the application of this SIA approach in assessing the sustainable development impact of the Doha Agenda, on developing countries and on the EU, will be completed in Spring 2003 (the results will be disseminated widely, with invitation to comment, on the project website: http://idpm.man.ac.uk/sia-trade). This is already providing a valuable test of the methodology and of the need for any further refinement, as a result of the experience gained and the comments received.

It is hoped that this first application of the methodology in carrying out detailed SIA studies of specific trade measures and of the Doha Agenda as a whole, will demonstrate to policymakers and other interested parties, both the feasibility and desirability of using the SIA approach as a tool for informing policy formulation and decision-making.

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COMMENTS ON THE PAPER " SUSTAINABILITY IMPACT ASSESSMENT METHODOLOGY: SIA STUDY OF PROPOSED WTO NEGOTIATIONS" BY COLIN KIRKPATRICK

Ian Vollbracht[9]

INTRODUCTION

These comments are provided on a personal basis and do not necessarily reflect the views of the European Commission. I work within the Economic and Financial Affairs Directorate General of the European Commission on trade policy and international macroeconomic issues. In this context, I have participated in a number of panels charged with selecting external consultants to conduct SIAs for the Commission. My background is in economics and I have also contributed to discussions, both internal to the Commission, and in external fora, as to the appropriate methodological approach for SIA. My comments therefore focus on the methodological aspects of Colin Kirkpatrick's paper. I will also add a few observations on how SIA consultants can best tailor their output so that key messages are well understood by the target audience.

METHODOLOGICAL ASPECTS

As an economist I am instinctively attracted to the SIA concept, since, in principle, SIA is about providing an analytical underpinning to (for the present discussion) trade policy initiatives. Such initiatives may have at their root a variety of political, economic or other motivations, but a thorough analysis of trade policy proposals, such as through an SIA, can add value by helping to shape the details of the policy measure so as to maximise economic, social and environmental benefits. SIA is also a communication tool for policy dialogue about a given trade policy proposal among interested and affected parties.

An often-quoted observation from economic theory is that a policymaker needs as many independent policy tools as he has policy goals. This suggests difficulties for the methodological design of an SIA that must serve both analytical and communication objectives. I therefore very much appreciate the broad sweep of Colin Kirkpatrick's paper. He provides a comprehensive overview of each of the stages of the SIA methodological process, with strong emphasis on what is practically possible and communicable to policymakers and other stakeholders.

In the short time available to me, I cannot cover all aspects of the methodological approach that Colin Kirkpatrick advocates. I would, however, like to pick up on a point he makes about the need for SIA to examine economic, social and environmental aspects systematically and consistently. This must be right, but I think that the **consistency** point is worth exploring in more detail. I would like, in particular, to consider the usefulness, and limits, of computable general equilibrium (CGE) modelling to SIA in this context. I will

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particularly focus on what I see as the advantages of the CGE approach at the "screening and scoping" stage of an SIA.

The key advantage of the *general equilibrium* approach is the full model consistency it necessitates. A partial approach that only looks at one area of policy in isolation risks missing out important feedback effects on other areas of the system in question. I acknowledge the problems related to CGE modelling, such as the need for restrictive assumptions and data issues[10], but the consistency property is crucial at the earliest stages of SIA analysis. I see CGE modelling as producing key intermediate goods that contribute to the final production of an overall SIA. A CGE model can give a *fully consistent* set of first estimates as to where the policy measure in question will have the biggest (economic) impact. CGE modelling thus identifies a series of sectors that are likely to be the most interesting candidates for much more detailed analysis. This detailed, sectoral work cannot be done by CGE modelling and herein lies a key value-added of the SIA consortium approach: environmental and social policy experts can examine those sectors that have been "red-flagged" by the CGE model. This further analysis is inherently sectoral and thus may not be fully consistent, in the sense that all feedback effects between sectors may not be taken into account. The main point, however, is that the sectors so analysed have been selected in a consistent manner.

CGE modelling at its current level of development is, in my view, not an adequate tool for making policy decisions, but it is a useful approach for helping analysts better to understand policy problems. I therefore see a role for CGE modelling in identifying for more detailed, sectoral work those areas in the economic system that will be most affected by the given policy change[11]. In terms of Colin Kirkpatrick's paper, I would thus place more emphasis on the usefulness of CGE modelling in the "causal chain analysis" discussed therein.

FROM SIA CONSORTIUM TO OUTPUTS FOR THE TARGET AUDIENCES

Colin Kirkpatrick's paper includes a very instructive typology of the different experts that should be included in an SIA consortium. His comprehensive list highlights the diversity of skills and analytical approaches that an SIA consortium must comprise if it is successfully to consider economic, environmental and social policy issues. I agree with his emphasis on the need for a core team of experts to oversee these varied inputs and to ensure that they fit into a consistent overall methodological approach. This function means not only project management and co-ordination, but also what one might call "translator" skills that enable, for example, an environmental expert on the management of fish stocks to communicate effectively with an economist whose model may have indicated that this sector is worth looking at in more detail.

[10] Data availability problems may be particularly severe in some cases, for example for some LDC countries. At the limit, this may seriously reduce the usefulness of the CGE approach.

[11] The recent SIA on the EU - Chile agreement, produced by a consortium headed by Planistat used CGE modelling in the manner advocated in this note. The final report is available at: http://www.planistat.com/SIA/en/reports.php

My final point concerns the communication of SIA results. Having argued in favour of a role for CGE modelling in SIA work, I am also aware that CGE output, particularly due to the "mechanistic" way in which it is produced, is very prone to being misunderstood or taken out of context. More generally, the "core team of experts" referred to in Colin Kirkpatrick's paper need to perform the difficult task of ensuring that economists, environmental and social policy experts "write the same language", such that the final policy conclusions of an SIA can be traced back through the analytical work that has led to them. I also see major advantages to the use of case studies to illustrate particular aspects of the research. The importance of a concise executive summary for key messages, and of a detailed table of contents so that the interested specialised reader can quickly find what he is looking for, should also not be underestimated in terms of the policy usefulness of a final SIA report.

CONCLUSION

I hope that these comments have gone some way to increasing the chances that future SIAs will be able better to achieve the twin objectives of policy analysis, and facilitating policy dialogue.

COMMENTS ON THE EC'S SUSTAINABILITY IMPACT ASSESSMENT METHODOLOGY

Robert R. Teh Jr[12].

I have two comments on the SIA methodology that has been developed for the European Commission. First, it appears to me that what we have here is not a sustainability impact assessment of trade but rather an assessment of the economic, social and environmental impacts of trade liberalisation. Second, there is a need to more explicitly incorporate a cost and benefit framework to the methodology to ensure that policymakers have the necessary information to consider the benefits, costs and trade-offs of various options available to them.

The major conceptual gap in the SIA methodology is that it does not have a rigorous definition of sustainable development which can provide a meaningful point of departure for the assessments. The current SIA methodology approaches the issue by seeking to link the outcome of trade negotiations with a set of economic, environmental or social indicators. However, the relationship of these indicators to the concept of sustainable development is not really explored or elaborated in a substantive way. In its famous definition, the Brundtland Commission characterized sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The central tension in this definition is how to manage the competing demands of different generations. There is an intrinsically intertemporal dimension to the definition that must be reflected in the assessment methodology.

One can think of several ways this definition of sustainability can be understood by an economist. One simple characterization is that sustainable development is a process that leaves the future generation with at least the same range of choices between growth and environmental resources as that faced by the present generation. Figure 1 describes the trade-off between growth and environment faced by the current generation. The present generation can have more of development but it comes at the cost of less environmental resources. This locus of possibilities is sketched out by curve ZZ. The present generation's preferences for growth and environment is given by welfare curve WW. The optimal choice for the present generation is given by point P, which implies a certain level of economic growth and a corresponding stock of environmental resources.

Development is sustainable if the set of choices between growth and protection of the environment that is bequeathed to future generations is at least as good as the choices faced by the current generation. In other words, development is sustainable if the present generation's drive for growth (its choice of the point P) does not shrink the locus of opportunities given by curve ZZ. Thus, the future generation must face a locus of choices that is at least as good as that represented by ZZ.

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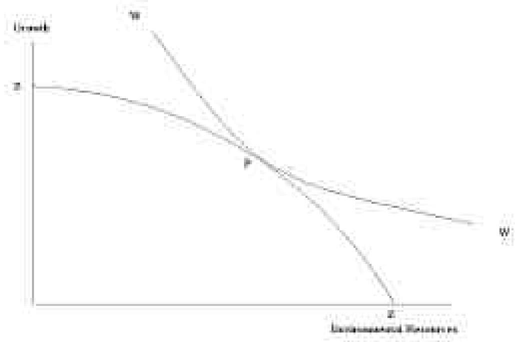
Figure 1: Growth–Environment Trade-off



This characterization of sustainable development implies that it is not enough to examine the impact of trade on a given set of indicators of sustainability, that is whether they go up on down. The assessment must be whether any deterioration crosses a threshold level so that the decline in environmental quality becomes irreversible or the present generation imposes too large a burden on future generations to remedy the resulting damage. I think that it is necessary for a methodology of sustainable impact assessment to address these types of conceptual issues. The discussion above is intended to show how some lines of inquiries could have proceeded and how the conceptual understanding of sustainability must be intimately linked with how indicators are collected and used. Given that these issues are not addressed at all in the current SIA methodology, what we then have is, at best, a combined environmental and social assessment of trade rather than a method for sustainability impact assessment of trade.

The second comment is the need to explicitly incorporate a cost and benefit framework in the SIA methodology.[13] With a cost-benefit framework, the decision-maker is able to rank the available options and determine whether her decision would increase welfare or not. In practice, the sustainability impact assessment is likely to conclude that some indicators will improve while others will deteriorate as a result of the trade agreement. The decision maker is then faced with difficult trade-offs - liberalising a specific trade measure may result in an improvement in some environmental indicators but a deterioration in others. Without a method for aggregating across the set of indicators, she will be unable to make a definite conclusion about the desirability of the agreement.

[13] This has been recommended by the UNEP's Reference Manual on the Integrated Assessment of Trade-related Policies, for instance.

One of the objectives of the assessments is to determine whether mitigation or flanking measures would be necessary to counteract any environmental risks arising from the trade agreement. However, this does not obviate the need for a cost-benefit calculation. Mitigation measures may not always be feasible; or they may be unable to completely offset the negative environmental or social impacts. Alternatively, the adoption of the mitigation measure itself may involve a cost. It may lead to higher costs of production and foregone trade and income. In the absence of a cost-benefit analysis of the predicted impacts of the trade agreement and of the proposed mitigation measure, the policymaker will have no basis for deciding whether the optimal outcome is to adopt the trade agreement without the accompanying mitigation measure, or to adopt both, or to change the initial negotiating stance.

Now it may be argued that policymakers will have to take other, i.e. non-economic, considerations into account when arriving at a decision. This is undoubtedly true. But the analyst's task is to provide the decisionmaker with as much information as he can on what various choices entail in economic terms, and a cost benefit analysis provides a transparent framework for him to do so, ultimately improving the public choice process.

ASSESSING THE IMPACT OF TRADE POLICY ON LABOUR MARKETS AND PRODUCTION

Joseph Francois

SUMMARY

How does trade policy affect patterns of production and employment, and how does this manifest itself in terms of adjustment costs? This paper is concerned with these issues, exploring how we approximate the production and employment effects of trade liberalization, and more broadly the effects of economic integration. The issue is clearly important, as there is a public perception that "globalization," however defined, is driving negative labour market trends. This in turn has coloured the willingness of the OECD governments, under pressure from NGOs and their own electorates, to push for further liberalization initiatives. It also colours our sense of developing country gains from liberalization. In this regard, the paper provides both a broad-brush overview of the literature on ex-post assessment, and a discussion of ex-ante measurement. Ex-ante measurement is illustrated with a CGE application involving a stylized EU enlargement.

At its most basic level, the measurement of the effects of trade liberalization on welfare generally involves comparison of welfare levels before and after liberalization, and after all factors of production have found their new long-run occupations. However, such calculations need to be adjusted for possible losses during the transition to the new long-run situation, in particular if this transition takes a long time. That is, proper welfare calculus needs to allow for *social adjustment costs*. The econometric literature on the impact of trade on labor markets, based on the historic experience of OECD economies, stresses this issue. This includes a focus on the displacement of labour within as well as between sectors, transition dynamics, cross-border outsourcing, and natural labour force turnover. Such effects map directly into the determination of the adjustment costs of policy changes, though they are likely to miss important issues (like market fragmentation and rigidities) especially in developing countries. A similar set of issues is highlighted in the computational model-based simulation literature.

Unfortunately, the measures available from computational exercises don't actually touch on several of the issues stressed in the literature on actual experience. In simulation models, we do not usually have the data or structure needed to model within sector (i.e. firm-specific) labour market churn. Neither do we offer an adequate treatment of outsourcing mechanisms. "Transition dynamics" is synonymous with investment processes rather than labour force movements in the computational literature. And while labour mobility and natural turnover clearly matter, we don't know enough yet to treat these issues adequately either. In short, while the computational part of the paper introduces indexes for labour market adjustment, it also stresses the need for more research.

ABSTRACT

This paper discusses the measurement of production and employment effects of trade policy, and more broadly the effects of economic integration and globalization. First, it provides a broad-brush overview of the ex-post literature linking trade to performance, such as measures of worker displacement, adjustment costs, and econometric evidence on trade and wages. It then defines structural impact indexes, illustrating their use with a stylized CGE model-based assessment of the impact of EU enlargement on the transition economies. Finally, the last section discusses the gap between our ex-post experience with adjustment costs, and what ex-ante methods actually tell us.

JEL Classification : D58, F16, J60.

Key Words : adjustment costs, labour displacement, output effects of trade liberalisation

EVALUATION DES IMPACTS DE LA POLITIQUE COMMERCIALE SUR LE MARCHÉ DU TRAVAIL ET LA PRODUCTION

RÉSUMÉ

Comment la politique commerciale affecte-t-elle les structures de la production et de l'emploi , et comment cela se manifeste-t-il en termes de coûts d'ajustement ? Cet article traite de ces questions en étudiant en détail la manière dont nous estimons les effets de la libéralisation commerciale sur la production et l'emploi, et plus généralement les effets de l'intégration économique. Cette question est évidemment importante, car l'opinion publique perçoit la « mondialisation », quelle que soit la manière dont elle est définie, comme ayant des effets négatifs sur le marché du travail. A son tour, cette perception négative a pesé sur la volonté des gouvernements des pays de l'OCDE, soumis à la pression des ONG et de leur propre électorat, à poursuivre de nouvelles initiatives en matière de libéralisation. Cette attitude altère aussi notre perception des gains de libéralisation pour les pays en développement. A cet égard, l'article propose à la fois une vue d'ensemble de la littérature sur les estimations ex post et un débat sur les évaluations ex ante. L'évaluation ex ante est illustrée par un calcul en équilibre général portant sur une maquette simplifiée de l'élargissement de l'Union Européenne.

A son niveau le plus simple, la mesure des effets de la libéralisation commerciale sur le bien-être implique généralement une comparaison des niveaux de bien-être avant et après la libéralisation, et après que tous les facteurs de production aient retrouvé leurs emplois de long terme. Cependant, de tels calculs ont besoin d'être ajustés en fonction des pertes possibles pendant la phase de transition vers la nouvelle situation de long terme, en particulier si la transition prend du temps. En d'autres termes, un calcul juste du bien-être doit tenir compte des *coûts sociaux d'ajustement*. La littérature économétrique traitant de l'impact du commerce sur les marchés du travail, basée sur l'expérience historique des pays de l'OCDE, insiste sur ces questions. Elles incluent les déplacements de main d'œuvre à l'intérieur ainsi qu'entre les secteurs, les dynamiques de la transition, la sous-traitance internationale et la rotation d'équilibre de la main d'œuvre. Ces effets ont une influence directe sur la détermination des coûts d'ajustement des changements de politiques, bien qu'il est fort possible qu'ils passent à côté de problèmes importants (tels que la fragmentation et les rigidités du marché), particulièrement dans les pays en développement. Les simulations effectuées avec des modèles calculables qui sont décrites dans la littérature portent sur des points similaires.

Malheureusement, les évaluations pratiquées dans les exercices de simulation n'abordent pas vraiment plusieurs questions importantes de la littérature empirique. Dans les modèles de simulation, nous n'avons pas en général les données ni les spécifications requises pour modéliser les perturbations du marché du travail internes aux secteurs (c'est-à-dire entre entreprises). De même nous ne traitons pas de façon adéquate les mécanismes de la sous-traitance. La «dynamique de transition » recouvre, pour les modélisateurs, plutôt les processus d'investissement que les mouvements de main d'œuvre. Et alors que la mobilité

du travail et la rotation d'équilibre de la main d'œuvre sont manifestement importants, nous n'en savons pas encore assez non plus pour traiter ces questions de manière appropriée. En fait, dans la partie de cet article consacrée aux simulations, nous présentons des indicateurs de l'ajustement des marchés du travail, et nous soulignons également la nécessité de poursuivre les recherches.

RÉSUMÉ COURT

Cet article traite de la mesure des effets de la politique commerciale, et plus généralement de l'intégration économique et de la mondialisation, sur la production et l'emploi. Tout d'abord est présentée une vue d'ensemble de la littérature sur les liens *ex post* entre commerce et performances économiques, comme les mesures des destructions d'emplois, des coûts d'ajustement, et les résultats économétriques reliant commerce et salaires. Ensuite des indices structurels d'impact sont définis ; à titre d'illustration ils sont utilisés pour évaluer de façon simplifiée à l'aide d'un MEGC l'impact de l'élargissement de l'UE sur les économies en transition. Enfin, la dernière section de l'article examine le décalage entre notre expérience tirée des études *ex post* des coûts d'ajustement, et ce que les méthodes *ex ante* nous apprennent réellement.

Classification JEL : D58, F16, J60

Mots-clefs : coûts d'ajustement, destruction d'emplois, effets de la libéralisation commerciale sur la production

ASSESSING THE IMPACT OF TRADE POLICY ON LABOUR MARKETS AND PRODUCTION[14]

Joseph Francois[15]

INTRODUCTION

How does trade policy affect patterns of production and employment, and how does this manifest itself in terms of adjustment costs? This paper is concerned with these issues, exploring how we approximate the production and employment effects of trade liberalization, and more broadly the effects of economic integration. The issue is clearly important, as there is a public perception that "globalization," however defined, is driving negative labour market trends. This in turn has coloured the willingness of the OECD governments, under pressure from NGOs and their own electorates, to push for further liberalization initiatives. It also colours our sense of developing country gains from liberalization.

The paper is organized as follows. Section 1 discusses econometric approaches to measurement of adjustment costs, while Section 2 discusses the literature on linkages between economic integration, division of labour processes, and labour market adjustment. Section 3 defines structural impact indexes for impact assessments. While these indexes can be used for ex-post or ex-ante assessments, their use is illustrated in a numeric (CGE-based) example. The final section concludes.

1. ADJUSTMENT COST MEASUREMENT

At its most basic level, the measurement of the effects of trade liberalization on welfare generally involves comparison of welfare levels before and after liberalization, and after all factors of production have found their new long-run occupations. However, such calculations need to be adjusted for possible losses during the transition to the new long-run situation, in particular if this transition takes a long time. That is, proper welfare calculus needs to allow for *social adjustment costs*[16]

A standard measurement of social adjustment costs is the value of output that is foregone in the transition to new long-run production patterns because of the time taken to reallocate factors from their pre- to their post-liberalization occupations. There are also other costs that are harder to quantify, such as the mental suffering of unemployed workers, which normally fall outside the realm of economic analysis. The magnitude of adjustment costs is a direct reflection of the speed at which the economy manages to redirect resources in

[14] This article has received funding from the European Commission (D.G. Research).

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[16] A more extensive discussion of adjustment costs is provided by Matusz (1997).

response to liberalization. For this reason, they depend on a large number of factors[17]. However, the flexibility of labour markets and credit markets is especially important. If firms in sectors with potential for expansion do not have strong incentives to hire new employees, for instance because of administrative regulations or externally imposed labour market contract requirements, the adjustment will be more costly than otherwise. Likewise, firms will need to invest in order to exploit new opportunities, and this requires access to credit. The possibility of smooth adjustment also depends on the functioning of other markets. For example, the possibility for labour to find alternative employment may depend on the housing market. At the same time, there may be a trade-off between displacement and efficiency gains.

Adjustment costs are also influenced by the degree of ease with which firms in *contracting* sectors are able to release factors. For instance, if production in these firms is maintained through government support, the adjustment process might be prolonged. This is not to say, however, that it would be economically desirable that factors are laid off immediately after liberalization. From a purely economic point of view, minimization of adjustment costs requires a careful balance between the speed at which factors are released and the speed at which they can be re-employed. It is sometimes argued that the existence of adjustment costs makes it desirable for the trade liberalization process itself to be gradual. The question of the appropriate speed of trade liberalization is complex, however, and typically also involves the question of political credibility.

In theory, trade liberalization may entail a net welfare loss if the gains are sufficiently small relative to the adjustment costs. However, such adjustment costs would have to be very large relative to the standard gains from trade liberalization in order to dominate the latter. Adjustment costs are temporary and must be set against an indefinite stream of future higher incomes. It would therefore take very large costs, or a very short-run perspective (i.e. a high discount rate) in order for the costs to outweigh the gains. This is further reinforced by the fact that the (static) gains from trade liberalization tend to grow over time as a result of general economic growth.

In addition to aggregate effects, one can also consider these costs from the point of view of individuals (*private* adjustment costs). One reason why these may be important is that private adjustment costs are typically unevenly distributed, as some factor markets work more smoothly than others to redirect resources that are freed up through liberalization. There may also be strong regional differences that imply that different factor owners experience different adjustment costs. The distributional consequences of adjustment can have two important ramifications. First, they may generally be perceived of as being undesirable, and may thus call for some form of government intervention on equity grounds, in contrast to social adjustment costs which might require government measures

[17] The question of the appropriate design of government measures to ease adjustment has been the focus of a recent analytical economic literature, see e.g. Journal of International Economics 36, 1994, which contains several contributions. There is also an empirical literature which considers the efficiency of adjustment programmes. A common finding is that the resources spent on these programmes do not reach the intended targets, but are appropriated by others, see eg. Richardson (1982).

on efficiency grounds. But, as always, the least-cost way of providing this assistance would very rarely be in the form of protection, but more plausibly as retraining, housing, income support, and so on.[18]

Another reason why adjustment costs may be important involves political economy. Private adjustment costs are significant determinants, together with the long–run effects of trade liberalization, of the identity of winners and losers from trade liberalization. They influence the line-up of interests that might oppose trade liberalization, despite any aggregate gains it may bring. There is a fair amount of empirical evidence that trade liberalization may entail significant losses for some groups. For instance, several studies report that replaced workers may earn substantially less in their new occupations, even several years after replacement. (Jacobson et al (1993a,b) provide examples of the former case for the United States, while a more positive picture is painted in Mills' and Sahn's (1995) study of Guinea.) Whether this is a temporary phenomenon, and thus an adjustment cost, or a permanent phenomenon, is often difficult to determine.

The empirical literature on the magnitude of adjustment costs from trade liberalization was rather thin until recently. This is probably a reflection of the perception among researchers during the 1960s and 1970s that adjustment costs were typically quite small in proportion to the aggregate gross gains, an impression that is supported by the limited number of studies that were undertaken. One approach has been to study outlays in Trade Adjustment Assistance (TAA) schemes in the United States. According to Richardson (1982), total outlays in trade adjustment assistance under the US Trade Expansion Act of 1962 were approximately US$75 million for the period 1962-75. The corresponding figure for assistance under the US Trade Act of 1974 for the period 1975-79 was approximately US$870 million, with a sharp increase in 1980-81 due to the auto-centred recession.

Another method which has also been employed in relation to temporary unemployment from trade liberalization is to obtain a rough estimate of the temporary income loss by multiplying an estimate of the average amount of time workers are unemployed with an estimate of their average wage. This method was employed in a series of papers in the mid-1970s. For instance, Bale (1974) estimated from a sample of workers assisted under the US Trade Expansion Act of 1962 that the average income loss was US$3,370 during 1969-70 for a worker who was displaced because of import competition, before taking into account such factors as trade adjustment assistance and unemployment insurance.

A different approach is taken by Takacs and Winters (1991) in their study of the likely effects of the removal of quantitative restrictions in the British footwear industry. A starting point of their analysis is the observation that there is a fairly high natural rate of turnover in the industry, even absent trade liberalization (almost 17 percent per year). Takacs and Winters estimate the adjustment costs and the long-run benefits from removal of these quantitative barriers, taking into account this turnover. The magnitude of these estimates varies according to the underlying assumptions that are used. However, the

[18] The World Bank (1997) discusses policy measures to ease adjustment costs from a developing country perspective.

authors report that even under their most pessimistic scenario, the adjustment costs are almost negligible in comparison to the potential gains from trade liberalization – that is, slightly less than £10 million in losses compared to £570 million in gains.

A more indirect way of assessing the magnitude of adjustment costs has been to estimate the share of the restructuring of trade that takes place *within* industries[19]. The basic idea is that it is easier for factors of production to move from one occupation to another in the same industry, rather than to switch industries. From this point of view one should expect increased import competition between developed countries to be associated with smaller adjustment costs per lost job than when the loss stems from expansion of trade associated with increased exploitation of comparative advantage.

There are also other methods of assessing the magnitudes of adjustment costs[20]. It should be noted, however, that regardless of the method employed, these calculations should be viewed with caution. For instance, since the costs and benefits of liberalization are typically distributed unevenly through time, they are sensitive to the assumed rate of discounting of future gains and losses - an assumption which by its very nature must be quite arbitrary. However, despite differences in methodological approach and in underlying assumptions, ex-post empirical studies typically convey the message that social adjustment costs are small, in aggregate, in comparison to the standard gains from trade liberalization. At the same time, they can be very significant for the individuals affected.

2. WAGES

While trade liberalization may enlarge the economic pie, its allocation can be affected by trade liberalization even as it is enlarged. Understandably, this is a highly sensitive issue. For this reason, though technology appears to emerge from the data as the current driving force behind recent labour market changes, the linkage between trade liberalization and labour market conditions will continue to be an important issue.

For the great majority of the research on the link between trade and wages, the logic of the argument is straightforwardly represented by the *Stolper-Samuelson theorem*, and the source of the problem is seen, more-or-less explicitly, to be trade with developing countries. (The Stolper-Samuelson theorem is derived from the same theoretical explanations of comparative advantage discussed earlier with respect to the allocation gains from trade. It points to an immediate link between trade prices and relative labour income.) Despite the beauty of the theory, a compelling argument against the plausibility of Stolper-Samuelson-based arguments is that trade with developing countries constitutes too small a share of OECD economic activity to generate effects of the magnitude observed in the 1980s. Another weakness in the story is evidence that the earnings/employment gap has

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[19] See, for example Greenaway et al. (1999).

[20] Examples of other empirical studies, employing a variety of methods, are Baldwin, Mutti and Richardson (1980), de Melo and Roland-Holst (1994), Magee (1972), de Melo and Tarr (1990), and Mutti (1978).

opened in the same direction across developing countries as well (see Wood 1997), suggesting that it may be technology rather than trade that is driving events.

Given the ease with which the HOS model yields an estimating framework, it is not surprising that the empirical literature on trade and wages has derived primarily from competitive models of the HOS family. By contrast, imperfectly competitive models come in a variety of forms, most of which do not yield as readily to econometric representation as do the competitive models. For this reason, work in imperfectly competitive frameworks has been largely CGE-based. Even so, we do have some econometric evidence of economic geography mechanisms, and related effects, outside the HOS framework. Building on the fundamental work of Ethier (1982) and Markusen (1990), Markusen and Venables (1997, 1999) develop a two-sector, two-factor model characterized by one conventional (i.e. constant returns to scale) sector and one sector characterized by monopolistic competition and division of labour induced external scale economies. Markusen and Venables are interested in North-South issues, so their two-country model involves endowment differences as well as the division of labour structure. Within this framework, the authors show that effects of a reduction in barriers to multinationalization have ambiguous effects on the wage premium. Using a similar production structure, Lovely and Nelson (2000) examine trade between similar countries and wages, Francois and Nelson (2001) analyze both trade and foreign direct investment between similar countries, and its effect on the wage premium. The recent book by Dluhosch (2000) and the paper by Burda and Dluhosch (2001) emphasize outsourcing and relative wages.

3. STRUCTURAL IMPACT INDEXES

The basic approach to ex-ante assessment (in a developed or developing country context) involves the application of a partial or general equilibrium simulation model. (See Francois and Reinert 1997). The next section provides an example, where we employ a number of indexes for tracking the structural impact of policy changes on economy-wide employment and output patterns. For the example, these are defined with respect to the *n* sectors in an applied general equilibrium model, though they could also be defined with respect to the population of firms within a sector (if we had the data and estimates of within-sector production and output variation). The first index is simple, representing percent changes in output at the sector level:

(1)
$$I_{1,j} = \frac{dQ_j}{Q_j} \cdot 100$$

sector output change index

The next two indexes are based on our measurement of output changes. These are basically variance-based indexes of our sector output deviation measure I_1, both un-weighted $\sigma(I_1)$ and weighted $\tilde{\sigma}(I_1)$.

(2)
$$I_2 = \sigma(I_{1,}) = \left\{ \left(\frac{1}{n-1} \right) \left[\sum_{j=1}^{n} \left(I_{1,j} - \left(\frac{1}{n} \right) \sum_{i=1}^{n} I_{1,i} \right)^2 \right] \right\}^{1/2}$$

un-weighted output deviation index

(3)
$$I_3 = \tilde{\sigma}(I_{1,}) = \left\{ \left(\frac{1}{n-1} \right) \left[\sum_{j=1}^{n} \left(\omega_j I_{1,j} - \left(\frac{1}{n} \right) \sum_{i=1}^{n} \omega_j I_{1,i} \right)^2 \right] \right\}^{1/2}$$

$$\text{where } \omega_i = n \cdot VA_i \cdot \left[\sum_{j=1}^{n} VA_j \right]^{-1}$$

weighted output deviation index

We then follow with a measure of the change in economywide employment earnings I_4.

(4)
$$I_4 = \left\{ \left[\frac{\sum_{i=1}^{n} W_{i,1}}{\sum_{j=1}^{n} L_{j,1}} \right] \cdot \left[\frac{\sum_{m=1}^{n} W_{m,0}}{\sum_{v=1}^{n} L_{v,0}} \right]^{-1} - 1 \right\} \cdot 100$$

average wage index

Next, we work in the example with a set of measures of the change in employment across sectors and across the economy. These are built on the change in employment at the sector level I_5.

(5)
$$I_{5,j} = \frac{dL_j}{L_j} \cdot 100$$

sector employment change index

Based on I_5, we also work with two variance-based indexes, an un-weighted index $\sigma(I_5)$ and a weighted index $\tilde{\sigma}(I_5)$. (Wage bills are used as weights, as this information is usually available. Of course, other weights, such as full-time equivalent jobs, could also be used).

(6) $$I_6 = \sigma(I_5) = \left\{ \left(\frac{1}{n-1} \right) \left[\sum_{j=1}^{n} \left(I_{5,j} - \left(\frac{1}{n} \right) \sum_{i=1}^{n} I_{5,i} \right)^2 \right] \right\}^{1/2}$$

un-weighted employment deviation index

(7) $$I_7 = \tilde{\sigma}(I_6) = \left\{ \left(\frac{1}{n-1} \right) \left[\sum_{j=1}^{n} \left(\phi_j I_{6,j} - \left(\frac{1}{n} \right) \sum_{i=1}^{n} \phi_j I_{6,i} \right)^2 \right] \right\}^{1/2}$$

$$\text{where } \phi_i = n \cdot W_i \cdot \left[\sum_{j=1}^{n} W_j \right]^{-1}$$

weighted employment deviation index

Finally, we also focus (where appropriate given model assumptions) on the change in total employment, as indexed by I_8.

(8) $$I_8 = \left\{ \left[\frac{\sum_{i=1}^{n} L_{i,1}}{\sum_{j=1}^{n} L_{j,0}} \right] - 1 \right\} \cdot 100$$

total employment index

Collectively, the indexes in equations (1) to (8) provide some indication of changes in the pattern of production and employment across sectors. No one of them really provides an adequate picture (as will be seen in the numeric example), though together they do provide some sense of the direction and desirability of relative changes induced by policy. This will be illustrated in the next section.

4. An Example

We now turn to a computational example to highlight the use and interpretation of the structural impact indexes defined above. This involves a large multi-region CGE model. The model includes monopolistic competition in industrial and service sectors as developed above. It also includes sluggish mobility of labour, as described in the annex. The experiment involves the pending enlargement of the EU, and its impact on the transition economies of Central and Eastern Europe. However, the reader should not take the results too seriously, but should instead focus on the pattern of variation in results and the apparent information content of various measures.

4.1. The model

The model is a multi-sector general equilibrium model, characterized by intermediate linkages and monopolistic competition. It is a version of the GTAP model (Hertel 1996), modified to include imperfect competition exactly as developed in the annex. (See Francois 1998). This means that Armington trade in industrial and service sectors, a feature of the standard GTAP model, is replaced with monopolistic competition. The Hertel and Francois papers provide full documentation on the theory and implementation of the model.[21]

Like most CGE models, this one is characterized by an input-output structure that explicitly links industries in a value added chain from primary goods, over continuously higher stages of intermediate processing, to the final assembling of goods and services for consumption. Inter-sectoral linkages are direct, like the input of steel in the production of transport equipment, and indirect, via intermediate use in other sectors. CGE models capture these linkages by modelling firms' use of factors and intermediate inputs. The most important aspects of the model used here are the following: (i) it covers all world trade and production; and (ii) it allows for scale economies and imperfect competition. Consumer demand is generated from a representative regional household with Cobb-Douglas preferences over sectoral composites. This is a departure from the standard GTAP specification of demand.

The multi-region model used here divides the world into sixteen regions: Germany (DEU) , France (FRA) , the Netherlands (NED), the rest of the EU (REU15), the recently confirmed candidate countries (CEECs), the Mediterranean economies (MED), North America (NAM), South America (SAM), China (CHINA), India (INDIA), high income Asia-Pacific economies (HINCPAS), other Asia-Pacific (OASPAC), Australia and New Zealand (AUSNZ), South Africa (SAF), Sub-Saharan Africa (SSA), and the rest of the world (ROW). Each region is modelled with 17 sectors: cereals (CERE), horticulture (HORT), sugar (SUGA), intensive livestock (INTLIV), cattle (CATLE), dairy products (DAIRY), other agriculture (OAGR), processed foods (PROCF), textiles and clothing (TEXT), extraction and mining (EXTR), chemicals and petrochemicals (CHEM), machinery and electrical machinery (MELE), other industry (OIND), trade services (TRAD), transport services (TRAN), business services (BSVC), and other services (OSVC). Each sector consists of differentiated products, and consumer and firm demand for these are generated by CES preferences. Government services are produced through a Cobb-Douglas technology, which means that government expenditure shares over product categories are fixed. Consumption is defined as a Cobb-Douglas composite of private and government consumption.

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21 The papers can be downloaded from www.agecon.purdue.edu/gtap, while the model files will be made available for the final version of this paper at www.intereconomics.com.francois. Note that there is a long history of including monopolistic competition in CGE models. Hence, under a different name, some CGE modellers have been working with "new geography" models since the early 1980s. See Francois and Roland-Holst (1997) on this point.

Scale economies and monopolistic competition are modelled in manufacturing and services, exactly as developed in the annex. In particular, based on evidence of scale economies (OECD 1997), we model sectors as being characterized by Chamberlinian large-group monopolistic competition for traded intermediate and final goods. Other sectors (primary products and agriculture) are characterized by constant returns and perfect competition, with output differentiated by regions (the Armington assumption). Formally, factors are combined according to a CES function, while intermediates are used in fixed proportions. Both approaches (Armington and monopolistic competition) have two significant ramifications: (i) intermediate input prices enters firms' cost functions, so price-raising trade barriers directly affect firms' costs, and (ii) firms' demands for each variety of intermediates, whether differentiated by region (Armington assumption) or firm (monopolistic competition) follows standard CES derived demand functions. With product differentiation in all sectors, the model supports two-way trade in all traded sectors. Trade and scale elasticities are reported in Table A1.

The cost of trade is modelled explicitly as consisting of a combination of trade and transport services. Revenue from non-frictional trade barriers are returned to the representative consumer in each region. This includes quota rents, which are generally modelled as accruing to exporters. Regional labour and capital supplies are assumed to be fixed. (Capital is held fixed so that we can focus on resource shifts, without the additional complication of resource accumulation.)

With the exception of substitution and scale elasticities, which are drawn from the literature, model parameters are calibrated to social accounting data from the 2002 revision of the Global Trade Analysis Project (GTAP) version 5.2 data base. The GTAP dataset includes information on national and regional input-output structure, bilateral trade flows, final demand patterns, and government intervention, and is benchmarked to 1997. Bilateral tariff data are based on World Bank and WTO data on post-Uruguay Round protection, and reflect differential bilateral weighting of detailed trade data within model sectors. In addition, a stylized version of Agenda 2000 is also imposed on the benchmark database.

4.2. The experiment

Our experiment involves (1) a reduction in frictional trading costs between the European Union and the CEECs, corresponding to 2 percent of the value of trade; (2) free agricultural trade and harmonization of all border measures; (3) extension of the CAP subsidy scheme, with subsidies at 25% of EU15 rates. It does not include capital market effects (see Baldwin et al 1996), since at this point in time these are most likely reflected already in expectations, and hence in the base data. Some sensitivity analysis is offered vis-à-vis the mobility of labour between sectors. This is captured by a parameter (technically an elasticity of transformation) as discussed in the annex.

We introduce two labour market closures. In the first, labour markets are flexible, and employment is fixed in aggregate for skilled and unskilled labour. In the second, wages are fixed in Europe (the EU and the CEECs), while employment adjusts. Taken together, these provide some bound on the likely set of wage and employment effects.

4.3. Results (structural impact)

What are the results of our experiment? The basic results are summarized in Tables 1 and 2 and Figures 1 and 2. These are based on the index measurements defined in equations (1) to (8). The basic pattern of results is similar with both rigid and flexible labour markets, at least on the output side. However, if one examines the results closely, on the employment side the effects are rather different. First, in Table 1, we have a contraction in the processed foods sector, other industry, and agriculture. The food and agriculture results follow from forcing harmonization of external border measures, while allowing subsidies in the EU15 for agriculture at a rate 300 percent above the rate in the CEECs. (The current proposal for enlargement has the CEECs receiving 25% of comparable EU15 CAP subsidies, even as external measures are harmonized.) There is also a dramatic expansion of textile and clothing production relative to the benchmark. We also have a dramatic increase in real wages, and a rise in the wages for unskilled workers relative to skilled workers.

What about adjustment costs? Our best approximation is the measures of deviation in output and employment. Here, Table 1 shows that the un-weighted index places excess weight on small sectors. When we introduce weighting, the apparent shifting of labour across sectors is reduced, with a standard deviation around 7 percent of employment rather than 9 percent. This is still a large number. The actual amount of labour displacement hinges on the ease with which workers are moved between sectors. In the flexible wage scenario, added mobility buys more worker movement between sectors, and in turn a greater efficiency gain and higher average wages. This comes at a price, however, as illustrated in Figure 1. Greater labour market flexibility, in this sense, buys greater wages at the cost of greater worker displacement.

The same pattern appears to hold in Figure 2, which is based on the rigid wage model results reported in Table 2. Again, we see an apparent trade-off between job creation and the general degree of labour flexibility. *However*, this is actually misleading. If we examine the raw employment numbers in Table 2, we can see that a good deal of the “churn” in the labour market involves new entrants (or re-entrants). In fact, roughly three-quarters of the volatility is associated with simple expansion. Increased flexibility, in a positive environment, yields much more rapid job growth than less flexible markets, with job growth far outpacing displacement.

The differences in Tables 1 and 2 highlight the importance of viewing indicators of this type collectively, rather than individually. Labour displacement may not be what it first appears, just as sector effects, uncontrolled for sector size, may be misleading with respect to adjustment pressures.

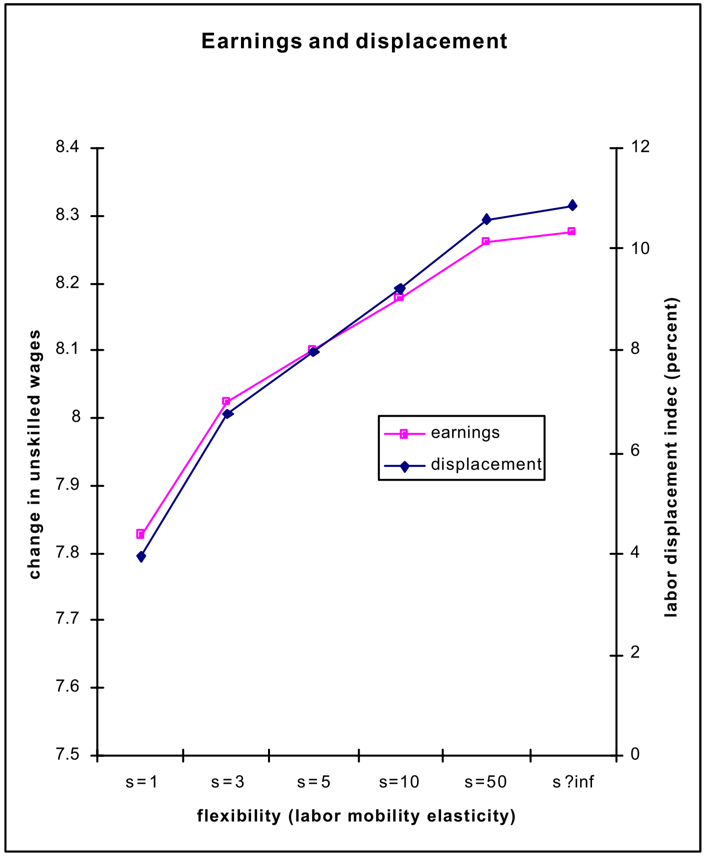
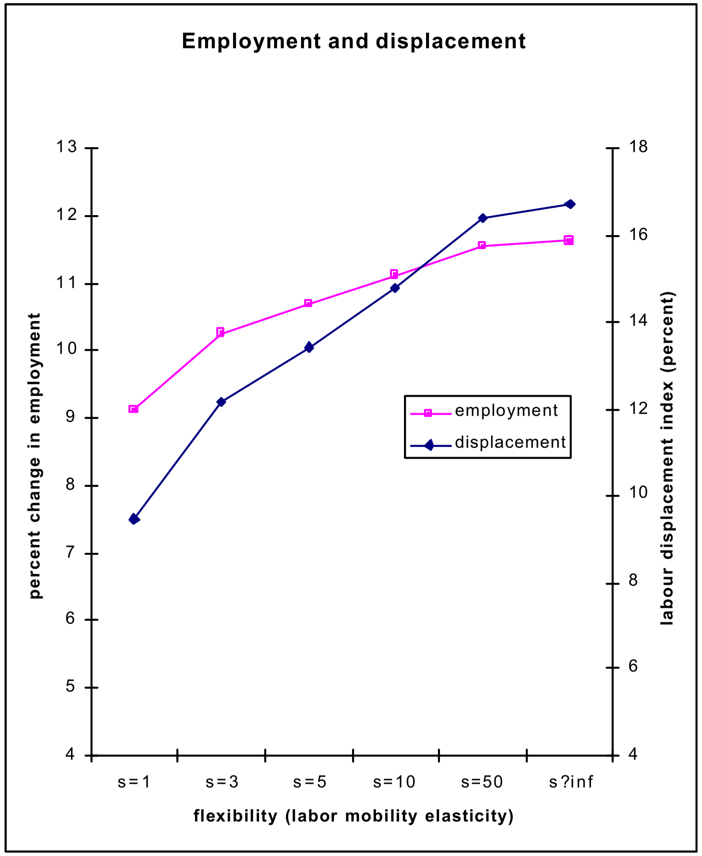
Figure 1	Figure 2
	

Table 1

Fixed Employment, Flexible Wages

equation		low s=1	s=3	LABOR MOBILITY s=5	s=10	s=50	high s inf
	Production Effects						
(1)	Percent changes in sector output						
	Cerals	-1.99	-2.71	-2.99	-3.27	-3.56	-3.62
	Horticulture & other crops	-3.25	-3.95	-4.20	-4.44	-4.68	-4.72
	Sugar, plants and processed	4.30	3.54	3.20	2.85	2.48	2.40
	Intensive livestock &products	-0.44	-0.76	-0.88	-1.00	-1.12	-1.14
	Cattle & beef products	4.44	4.61	4.65	4.67	4.68	4.68
	Milk & dairy	3.04	3.11	3.12	3.12	3.12	3.11
	Other agriculture	-0.91	-1.28	-1.42	-1.57	-1.71	-1.74
	Processed food products	-8.23	-10.47	-11.36	-12.25	-13.17	-13.35
	Textiles, leather & clothing	15.06	21.91	24.96	28.23	31.83	32.55
	Extraction industries	-0.41	-0.61	-0.69	-0.77	-0.86	-0.88
	Petro & chemicals	1.12	1.11	1.11	1.10	1.09	1.09
	Metal and electotechnical ind	6.00	6.82	7.03	7.16	7.24	7.24
	Other industries	-3.77	-4.81	-5.25	-5.69	-6.15	-6.25
	Trade services	-0.83	-0.95	-1.01	-1.06	-1.12	-1.14
	Transport services	2.21	2.02	1.91	1.79	1.64	1.60
	Business, financial & communnications services	-2.05	-2.35	-2.47	-2.59	-2.71	-2.73
	Other private and public services	-1.02	-1.23	-1.31	-1.38	-1.45	-1.47
(2)	unweighted output deviation index	5.06	6.76	7.51	8.31	9.20	9.38
(3)	weighted output deviation index	4.40	5.68	6.22	6.80	7.43	7.55
	Employment Effects						
(4)	Unskilled wages (average change)	7.83	8.02	8.10	8.18	8.26	8.28
(4)	Skilled wages (average change)	6.37	6.54	6.61	6.67	6.73	6.75
(6)	Unweighted employment deviation index -- unskilled	3.52	5.90	6.93	8.01	9.21	9.45
(6)	Unweighted employment deviation index -- skilled	3.60	6.05	7.11	8.24	9.48	9.73
(7)	Weighted employment deviation index -- unskilled	3.94	6.77	7.97	9.23	10.60	10.88
(7)	Weighted employment deviation index -- skilled	2.14	3.48	4.00	4.53	5.09	5.20

Table 2

Flexible Employment, Fixed Wages

equation		low s=1	s=3	LABOR MOBILITY s=5	s=10	s=50	high s inf
	Production Effects						
(1)	Percent changes in sector output						
	Cerals	1.95	1.34	1.11	0.89	0.66	0.62
	Horticulture & other crops	0.57	-0.12	-0.33	-0.54	-0.73	-0.76
	Sugar, plants and processed	8.53	8.01	7.77	7.50	7.22	7.17
	Intensive livestock &products	3.37	3.17	3.11	3.06	3.02	3.02
	Cattle & beef products	8.55	8.96	9.10	9.23	9.36	9.39
	Milk & dairy	7.08	7.43	7.55	7.68	7.81	7.83
	Other agriculture	2.45	2.25	2.20	2.14	2.09	2.08
	Processed food products	-3.87	-5.97	-6.83	-7.69	-8.59	-8.77
	Textiles, leather & clothing	23.34	32.68	36.85	41.32	46.29	47.28
	Extraction industries	1.86	1.42	1.28	1.16	1.03	1.00
	Petro & chemicals	5.01	5.44	5.59	5.75	5.91	5.94
	Metal and electotechnical ind	11.13	12.53	12.92	13.22	13.45	13.48
	Other industries	0.54	-0.03	-0.30	-0.59	-0.91	-0.97
	Trade services	2.83	3.29	3.46	3.63	3.79	3.83
	Transport services	6.05	6.43	6.53	6.60	6.65	6.66
	Business, financial & communnications services	1.39	1.60	1.68	1.74	1.81	1.82
	Other private and public services	3.34	3.56	3.65	3.74	3.83	3.85
(2)	unweighted output deviation index	5.98	8.21	9.21	10.28	11.47	11.71
(3)	weighted output deviation index	5.85	7.35	8.01	8.71	9.49	9.65
	Employment Effects						
(8)	Unskilled employment (economywide change)	9.14	10.26	10.69	11.11	11.56	11.64
(8)	Skilled employment (economywide change)	7.48	8.37	8.73	9.08	9.45	9.52
(6)	Unweighted employment deviation index -- unskilled	4.63	7.66	9.00	10.44	12.04	12.37
(6)	Unweighted employment deviation index -- skilled	4.45	7.54	8.91	10.39	12.03	12.36
(7)	Weighted employment deviation index -- unskilled	9.46	12.15	13.42	14.81	16.40	16.72
(7)	Weighted employment deviation index -- skilled	15.70	16.76	17.24	17.76	18.33	18.44

CONCLUSION

This paper is concerned with metrics used for the measurements of the output and employment effects of trade and trade policy, and their implications for assessing adjustment costs and the sustainability impact of policy. The paper provides both a broad-brush overview of the literature on ex-post assessment, and a discussion of ex-ante measurement. Ex-ante measurement is illustrated with a CGE application involving a stylized EU enlargement.

The econometric literature, based on the historic experience of OECD economies, stresses a number of issues. These include the displacement of labour within as well as between sectors, transition dynamics, cross-border outsourcing, and natural labour force turnover. These map directly into the determination of the adjustment costs of policy changes, though they are likely to miss important issues (like market fragmentation and rigidities) especially important in developing countries. A similar set of issues is highlighted in the computational model-based simulation literature. Unfortunately, the measures available from computational exercises don't actually touch on several of the issues stressed in the literature on actual experience. In simulation models, we do not usually have the data or structure needed to model within sector (i.e. firm-specific) labour market churn. Neither do we offer an adequate treatment of outsourcing mechanisms. "Transition dynamics" is synonymous with investment processes rather than labour force movements in the computational literature. And while labour mobility and natural turnover clearly matter, we don't know enough yet to treat these issues adequately either. In short, we need more research.

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ANNEX: SCALE ECONOMIES AND LABOUR MOBILITY IN THE MODEL

This annex is concerned with critical structural features of the CGE model used in Section 4 to illustrate the use of structural impact indexes. This includes representation of scale economies, labour mobility, and basic model parameters.

A.1 VARIETY SCALING

We start with a repesentation of trade under monopolistic competition that involves "variety-scaled" rather than physical output. This approach buys us a great deal of analytical simplicity when we turn to stability properties and the scope for inter-sectoral adjustment. Differentiated goods may be differentiated consumer goods, or producer goods that are assembled before the final good is sold locally. In either interpretation, there will be variety-related benefits to location. These benefits are further magnified in the computational section of the paper, where we also add intermediate linkages, reinforcing the advantages of location.

We first assume that individual firms producing variety x_j of good X are monopolists working under a homothetic cost function defined over an input price vector ω and subject to a fixed cost ad constant marginal cost. Free entry forces the standard average cost pricing solution, alongside the monopoly mark-up rule. The elasticity of is derived from standard S-D-S preferences, and hence is a constant value σ (which also equals the elasticity of substitution. Formally, in the X sector, we have the following cost and price relationships:

(A1) $$C(x) = \left[\alpha + \beta \cdot x\right] \cdot f(\omega)$$

(A2) $$P \cdot \left[1 - \frac{1}{\sigma}\right] = \beta \cdot f(\omega)$$

(A3) $$P = \left[\frac{\alpha}{x} + \beta\right] \cdot f(\omega)$$

In equations (A1)-(A3), P denotes price, C(.) denotes total cost for the firm producing x, and f(ω) is the linear homothetic cost function for a bundle of inputs (designated Z below). Taken together, equations (A2) and (A3) mean that firms are of an identical size (we have a symmetric equilibrium), and that change in industry scale will be proportionate to change in the number of varieties in the industry. In particular, we will have:

(A4) $$x = \frac{\alpha \cdot (\sigma - 1)}{\beta}$$

(A5) $$P = \frac{\beta \cdot f(\omega) \cdot \sigma}{(\sigma - 1)}$$

The scale of individual firms will be fixed, while the equilibrium price for each individual variety will be a linear function of the cost of input bundle Z. The demand for individual varieties follows from the standard S-D-S aggregation function:

$$\text{(A6)} \qquad q = \left[\sum_{i=1}^{n} g \cdot x_i^{\rho} \right]^{1/\rho}$$

In equation (A6), the term g denotes a constant applied to each variety. The elasticity of substitution of substitution will be $\sigma=1/(1-\rho)$, where $0<\rho<1$. For the moment, assume that we have two sources of varieties, designated 1 and 2. These sets of varieties originate in different countries. We will maintain the large group assumption throughout (i.e. demand elasticities remain unchanged), but now we subdivide equation (A6) to reflect the split sourcing of varieties. Note that, as long as we maintain the assumption of symmetry across firms from source 1 and 2, then we will consume identical quantities over all source r varieties.

$$\text{(A7)} \qquad q = \left[n_1 \cdot g_1 \cdot x_1^{\rho} + n_2 \cdot g_2 \cdot x_2^{\rho} \right]^{1/\rho}$$

In equation (A7), the subscript now designates (identical) varieties from a given national source, and n_r denotes the number of varieties associated with that source. Note that we have a CES weight that applies identical across varieties from a given source. We next modify equation (A7) so that it is defined over aggregate physical quantities (i.e. X=nx).

$$\text{(A8)} \qquad q = \left[n^{1-\rho}{}_1 \cdot g_1 \cdot X_1^{\rho} + n_2^{1-\rho} \cdot g_2 \cdot X_2^{1-\rho} \right]^{1/\rho}$$

If we hold variety constant, then equation (A8) is operationally identical to an Armington aggregation function. We will next write equation (A8) purely in terms of variety-scaled quantities V, so that we can simplify the demand side of the model by specifying it in terms of variety-scaled output. This involves one last rearrangement of equation (A8).

$$\text{(A9)} \qquad q = \left[g_1 \cdot V_1^{\rho} + g_2 \cdot V_2^{\rho} \right]^{1/\rho}$$

$$\text{(A10)} \qquad V_i = n_i^{1-\rho} \cdot X_i$$

On the demand side, we will work directly with equation (A9). Variety effects are embodied in the variety-scaled quantity defined by equation (A10), which we will treat as a supply-side phenomenon. Written in this way, variety works like a regional quality or scale effect that is realized at the industry level.

We turn next to the supply side of the model. We focus on sectoral output to start, but will later embed this structure into a multi-sector framework. On the supply side, assume that in country i bundles Z_i are available for production of varieties x_i of good X. From equation (4), we then have the following:

$$\text{(A11)} \quad n_i = \frac{Z_i}{2 \cdot \alpha_i \cdot (\sigma - 1)}$$

$$\text{(A12)} \quad X_{iT} = \frac{Z_i}{\alpha_i \cdot \beta_i}$$

where X_{iT} represents total physical production of X in country i. Because expansion of the X sector involves entry of identically sized firms, both physical output and variety are linear in input of bundles Z. Putting these two terms together with equation (A10), we can derive the implicit sectoral production function for variety-scaled output V.

$$\text{(A13)} \quad V_{iT} = \frac{2 \cdot \alpha_i \cdot (\sigma - 1)^{\frac{\rho - 1}{\rho}}}{\alpha_i \cdot \beta_i} \cdot Z_i^{1/\rho}$$

or to simplify

$$\text{(A14)} \quad V_{iT} = A \cdot Z_i^{1/\rho} = \Theta(Z_i)$$

Taken together, equations (A9) and (A14) let us simplify (in a useful way) the mathematics of production and trade with specialization-based returns to scale. Basically, sectoral demand is CES and defined over variety-scaled quantities from all sources, while sectoral supply of variety-scaled varieties exhibits a form of external scale economies common in the literature. Our representation of the model works, in reduced form, like a standard Armington model with external scale economies. Working with Armington-type quantities helps in isolating the stability properties of this class of models, and their sensitivity to factor mobility issues.

A.2 THE SUPPLY SIDE: STABILITY AND THE SCALE OF LOCAL ADJUSTMENT

We now want to embed the production side of the model into a general equilibrium framework. This will allow us to explore, analytically, the relationship between local agglomeration effects (due to variety) and the adjustment of output to price shocks. To do this, we assume a transformation technology between bundles Z and a homogeneous good Y. Factor markets are assumed competitive, so that the price of Z will correspond to the marginal rate of transformation between Z and Y. Furthermore, because we have average cost pricing vis-à-vis equation (A14), we can also map the supply-side price of V directly to the price of Z, and hence to the supply response in V and Z as we move along the production possibility frontier.

Our transformation technology, in reduced form, is represented as follows:

(A15) $$Y_i = \gamma_i(Z_i) \qquad \gamma' < 0, \gamma'' < 0$$

The price of bundles will be the following:

(A16) $$\frac{P_{Zi}}{P_{Yi}} = \frac{f(\omega)_i}{P_{Yi}} = -\gamma'$$

Average cost pricing means that we will also have

(A17) $$P_{Vi} = Z_i^{1-1/\rho} \cdot P_{Zi} = -\gamma' \cdot Z_i^{1-1/\rho} \cdot P_{Yi}$$

Making a substitution of (A17) into (A16) and solving for percent changes, we can derive the following.

(A18) $$\hat{P}_{Vi} - \hat{P}_{Yi} = Z_i \cdot \left[\frac{\gamma''}{\gamma'} - \frac{\Theta''}{\Theta'} \right] \cdot \hat{Z}_i$$

Equation (A18) relates changes in equilibrium supply of Z to changes in the relative prices of V and Y. The first term captures the relative curvature of the production possibility frontier (defined over bundles and Y), while the second term captures the relative curvature of the Θ function, which depends on variety effects. In a constant returns to scale model, the second term vanishes, and we simply have a variation of the classic Jones-type equation relating changes in supply to changes in relative prices. In the present setting, however, the presence of variety-specialization effects complicates the analytical mix.

Consider the case where we have local stability (in the sense that the sign of equation (A18) is positive). For a policy shock ultimately manifested, at least to producers, as a shift in producer prices, the corresponding magnitude of the shift in output will depend on how strong the scale effect is, as transmitted through the Θ function. The stronger it is, the greater the output response associated with a given price change, if equation (A17) is to hold. In other words, even for local adjustment from one stable equilibrium to another, how local such adjustment to a price shock will actually be will depend on the magnitude of scale effects. The larger the scale effects, the greater the corresponding shift in resources associated with an observed shift in relative prices. Of course, if the sign of equation (A18) is negative, then the local equilibrium is unstable, with a well-known potential for corner solutions (Francois and Nelson 2002).

A.3 FACTOR MOBILITY AND OUTPUT ADJUSTMENT

We now turn to the issue of local adjustment, and the role of factor mobility. By factor mobility, we are not referring to cross-country movement of factors. While this is an important theme in the recent geography literature and older scale economy literature (Krugman and Venables 1995; Markusen 1988; Rivera-Batiz and Rivera-Batiz 1991), our concern instead is the ability of factors (and in particular labour) to move between sectors within a country as employment opportunities shift. In terms of equation (A18), the inter-sectoral mobility of labour can be examined through its impact on the curvature of the γ function.

To develop this issue further, we will impose more structure on the γ function. In particular, we follow the older literature on inter-sectoral factor mobility (see for example Casas 1984; Hertel and Tsigas 1996) and assume that a constant elasticity of transformation will characterize our ability to shift resources between the Z and Y sector. In generic terms, this may follow from underlying differences in technology across sectors, as well as from factor mobility. However, for the moment, we focus on factor mobility.

Formally, the γ function that can be derived from a CET is represented as follows:

$$\text{(A19)} \qquad Y = \gamma(Z) = \left[\frac{Q^{\phi}}{a} - \frac{b}{a} \cdot Z^{\phi} \right]^{1/\phi}$$

In equation (A19), the term $\varphi>1$, and we will have an elasticity of substitution along the ZY frontier that is concave to the origin, and characterized by a constant elasticity or transformation $\Omega=1/(\phi-1)$, where $1<\Omega\leq\infty$. With an infinite transformation elasticity, the transformation frontier is linear.

Given equations (A14) and (A19), equation (A18) then can be written as follows:

$$\text{(A20)} \qquad \hat{P}_{Vi} - \hat{P}_{Yi} = Z_i \cdot \left[\left\{ (\phi - 1) \cdot (1 + Z^{\phi} \cdot (b/a) \right\} + \left\{ 1 - 1/\rho \right\} \right] \cdot \hat{Z}_i$$

The first term in brackets {} captures the curvature of the CET, through the parameter ϕ and our location on the transformation frontier, while the second term captures variety scaling effects.

Note that in the large group case, with homothetic cost functions, the variety-scaling term is actually a constant, so that local stability ends up depending entirely on variations in the curvature of the transformation frontier. This actually characterizes much of the recent literature, which employs Ricardian single factor models (i.e. linear transformation surfaces). In effect, this approach assumes, in reduced form, that corner solutions will be highly likely, along the lines of Kemp's (1964) work on Ricardian models with external scale economies.

In the body of the paper, we employ equation (A19), in a multi-sector general equilibrium model including intermediate linkages and monopolistic competition (a.k.a. a computational geography model) with a range factor mobility values.

A.4 MODEL PARAMETERS

Model parameters are listed below. The model is as described in Hertel and Tsigas (1996) and Francois (1998). CDRs are used to calibrate output-scale elasticities for variety-scaled output.

Table A1

Model Parameters

		A	B	C	D = (B-1)/B	E = 1/D
		trade substitution elasticities (regional differentiation)	average markup levels	elasticity of substitution in value added	implied CDRs	trade substitution elasticity (firm differentiation)
CERE	Cerals	2.200	1.000	0.246	0.000	2.200
HORT	Horticulture & other crops	2.200	1.000	0.246	0.000	2.200
SUGA	Sugar, plants and processed	2.200	1.000	0.639	0.000	2.200
INTLIV	Intensive livestock &products	2.497	1.000	0.545	0.000	2.497
CATLE	Cattle & beef products	2.453	1.000	0.571	0.000	2.453
DAIRY	Milk & dairy	2.200	1.000	0.645	0.000	2.200
OAGR	Other agriculture	2.754	1.000	0.203	0.000	2.754
PROCF	Processed food products	2.472	1.125	1.120	0.111	8.983
TEXT	Textiles, leather & clothing	3.316	1.126	1.260	0.112	8.909
EXTR	Extraction industries	2.800	1.177	0.200	0.151	6.638
CHEM	Petro & chemicals	2.050	1.200	1.260	0.167	6.005
MELE	Metal and electotechnical ind	3.386	1.212	1.260	0.175	5.720
OIND	Other industries	2.299	1.202	1.260	0.168	5.946
TRAD	Trade services	1.900	1.273	1.680	0.214	4.670
TRAN	Transport services	1.900	1.273	1.680	0.214	4.670
BSVC	Business, financial & commun. services	1.900	1.273	1.260	0.214	4.670
OSVC	Other private and public services	1.975	1.273	1.286	0.214	4.670

SUSTAINABLE IMPACT ANALYSIS: THE USE OF COMPUTABLE GENERAL EQUILIBRIUM MODELS

Christoph Böhringer

SUMMARY

Nearly all governments and multinational firms have committed themselves to the overall concept of *Sustainable Development*. Yet, *Sustainable Development*, which is not just about the environment, but about the economy and our society, has proven hard to define. One reason for this is that *Sustainable Development* explicitly incorporates a (normative) equity dimension, which is difficult to address on scientific grounds. Another reason is that the scope of the sustainability concept seems prohibitively comprehensive to make it operational in concrete practice. Nonetheless, societal policy is challenged to come up with pragmatic approaches to *Sustainable Development* and - to this end - requires robust advice from the scientific community. Inherently, the three dimensions of *Sustainable Development*, i.e. environmental quality, economic performance (gross efficiency) and equity concerns are intertwined and subject to tradeoffs.

The quantification of tradeoffs as a prerequisite for any rational policy debate 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 in the economy affecting potential indicators of *Sustainable Development*. In the end, the decisions how to resolve potential tradeoffs must be taken on the basis of societal values and judgements. However, model-based analysis puts decision making on an informed basis rather than on fuzzy or contradictory hunches.

The paper advocates computable general equilibrium (CGE) models as a methodological tool that is particularly suitable for assessing the impacts of policy interference on environmental quality, economic performance and equity. These models can incorporate lots of sustainability (meta-)indicators in a single consistent framework and allow for a systematic quantitative tradeoff analysis along the three dimensions of sustainability. Decomposition methods can be employed to better understand the complex adjustment mechanisms triggered by exogenous policy changes. The decomposition of general equilibrium results may also deliver valuable information for the proper design of policies. Systematic sensitivity analysis allows for the robustness test of model results with respect to uncertainties in the model's parameterization space. Furthermore, recent computational developments permit the formulation of optimal policy problems within large-scale CGE models. This class of models then can help to determine *optimal* policy choices for sustainable development.

ABSTRACT

This paper advocates computable general equilibrium (CGE) models as a methodological tool that is particularly suitable for assessing the impacts of policy interference on environmental quality, economic performance and equity. Recent developments in the field are presented that may further strengthen the role of CGE models in applied sustainable impact analysis. These developments include (i) decomposition procedures of general equilibrium effects that deliver a better understanding of key determinants for policy effects, (ii) the embedding of large-scale general equilibrium models in an optimal policy framework that considerably widens the scope of policy analysis, and (iii) systematic sensitivity analysis to test the robustness of model results with respect to uncertainties in the model's parameterization space.

JEL Classification: C68, D61, F17, Q50

Key Words: computable general equilibrium models, cost-benefit analysis, trade, environment

ANALYSE D'IMPACT EN TERMES DE DURABILITÉ : L'UTILISATION DE MODÈLES D'ÉQUILIBRE GÉNÉRAL CALCULABLES

RÉSUMÉ

Presque tous les gouvernements et entreprises multinationales se sont engagés à respecter le concept général de *développement durable*. Cependant, le concept de *développement durable*, qui ne concerne pas uniquement l'environnement mais aussi l'économie et la société, s'est avéré difficile à définir. L'une des raisons est que le concept de *développement durable* inclut explicitement une notion d'équité, dimension (normative) difficile à aborder sur des bases scientifiques. Une autre raison est que le domaine couvert par le concept de durabilité semble trop vaste pour permettre une mise en œuvre concrète. Néanmoins, les politiques «sociétales » sont mises au défi de proposer des approches pragmatiques du *développement durable* et, à cette fin, ont besoin des conseils de la communauté scientifique. Fondamentalement, les trois dimensions du *développement durable*, c'est-à-dire la qualité de l'environnement, les performances économiques (efficacité brute) et les questions d'équité, sont liées et doivent faire l'objet d'arbitrages.

Traduire ces choix en chiffres, condition préalable à tout débat politique rationnel, nécessite l'utilisation de techniques de modélisation numérique. Il n'y a tout simplement aucun autre moyen de réfléchir systématiquement et rigoureusement aux interactions entre les nombreuses forces dans l'économie qui affectent les indicateurs potentiels du *développement durable*. Au bout du compte, les décisions d'arbitrage entre les choix potentiels doivent être prises sur la base de valeurs et de jugements sociétaux. Cependant, l'utilisation de modèles permet de baser les prises de décisions sur des informations plutôt que sur des intuitions confuses ou contradictoires.

Cet article préconise l'utilisation des MEGC comme outil méthodologique particulièrement approprié pour évaluer les impacts des politiques sur la qualité de l'environnement, les performances économiques et l'équité. On peut incorporer dans ces modèles un grand nombre de (meta-)indicateurs de durabilité dans un même cadre cohérent, ce qui permet une analyse systématique chiffrée des arbitrages entre les trois dimensions de la durabilité. Des méthodes de décomposition peuvent être utilisées pour mieux comprendre les mécanismes complexes d'ajustement qui résultent de changements exogènes de politique. La décomposition des résultats obtenus avec les MEGC peut aussi fournir des informations utiles pour la mise au point de politiques appropriées. Une analyse de sensibilité systématique permet de tester la robustesse des résultats des modèles quant aux incertitudes liées au paramétrage. En outre, des avancées récentes dans la programmation permettent de formuler des problèmes d'optimisation de politiques à l'intérieur de MEGC de grande taille. Ce type de modèle peut alors aider à déterminer des politiques *optimales* pour le développement durable.

RÉSUMÉ COURT

Cet article préconise l'utilisation des MEGC comme outil méthodologique particulièrement approprié pour évaluer les impacts des politiques sur la qualité de l'environnement, les performances économiques et l'équité. L'auteur présente les avancées récentes dans ce domaine, qui peuvent encore renforcer le rôle des MEGC dans l'analyse appliquée des impacts en termes de durabilité. Ces avancées comprennent : (i) les procédures de décomposition des effets d'équilibre général qui permettent de mieux comprendre les déterminants-clés des effets des politiques, (ii) l'intégration de modèles d'équilibre général de grande dimension dans un algorithme d'optimisation qui étend considérablement la portée de l'analyse des politiques, et (iii) une analyse de sensibilité systématique pour tester la robustesse des résultats des modèles quant aux incertitudes liées au paramétrage.

Classification JEL: C68, D61, F17, Q50

Mots-clefs: modèles d'équilibre général calculable, analyse coûts-bénéfices, commerce, environnement

SUSTAINABLE IMPACT ANALYSIS: THE USE OF COMPUTABLE GENERAL EQUILIBRIUM MODELS[22]

Christoph Böhringer[23]

INTRODUCTION

In 1987, the report of the World Commission on Environment and Development (WCED or Brundtland Commission) defined *Sustainable Development* as "development which meets the needs of the present without compromising the ability of future generations to met their own needs". In June 1992, the Rio Earth Summit concluded that "the right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.". *Sustainable Development* has meanwhile become one of the most prominent catchwords on the world political agenda. Nearly all governments and multinational firms have committed themselves to the overall concept of *Sustainable Development*. Yet, *Sustainable Development*, which is not just about the environment, but about the economy and our society, has proven hard to define. One reason for this is that *Sustainable Development* explicitly incorporates a (normative) equity dimension, which is *„so hopelessly subjective that it cannot be analyzed scientifically"* (Young, 1994). Another reason is that the scope of the concept seems prohibitively comprehensive to make it operational in concrete practice.

Nonetheless, societal policy is challenged to come up with pragmatic approaches to *Sustainable Development* and - to this end - requires robust advice from the scientific community. Inherently, the three dimensions of *Sustainable Development*, i.e. environmental quality, economic performance (gross efficiency) and equity concerns are intertwined and subject to tradeoffs. Accomplishing one objective frequently means backpedaling on another. Since economics is the study of tradeoff, this means that there is plenty for economists to contribute in order to make the concept of *Sustainable Development* operational. One important contribution over the last years has been the assessment of external costs as a prerequisite towards "getting the prices right". Given full information on external costs, two aspects of *Sustainable Development*, namely economic performance (gross efficiency) and the environmental quality, can be merged to a comprehensive net efficiency dimension. Furthermore, while economics has little to say on equity *per se*, the sound economic quantification of distributional effects for different

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agents and tradeoffs between equity and efficiency objectives is a prerequisite for any rational policy debate.

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*. In the end, the decisions how to resolve potential tradeoffs must be taken on the basis of societal values and judgements. However, model-based analysis puts decision making on an informed basis rather than on fuzzy or contradictory hunches.

Given the broad agenda of *Sustainable Development*, the objective of this paper is to advocate computable general equilibrium (CGE) models as a methodological tool that is particularly suitable for assessing the impacts of policy interference on environmental quality, economic performance and equity. Recent developments in the field are presented that may further strengthen the role of CGE models in applied sustainable impact analysis. These developments include (i) decomposition procedures of general equilibrium effects that deliver a better understanding of key determinants for policy effects, (ii) the embedding of large-scale general equilibrium models in an optimal policy framework that considerably widens the scope of policy analysis, and (iii) systematic sensitivity analysis to test the robustness of model results with respect to uncertainties in the model's parameterization space.

The structure of the paper is as follows. Section 1 provides a brief appraisal of the CGE approach and sketches the generic structure of a multi-sector, multi-region CGE model for applied policy analysis. Section 2 describes recent methodological developments and illustrates their policy usefulness in the context of concrete policy simulations. The last section concludes.

1. THE GENERIC CGE APPROACH TO (SUSTAINABLE) IMPACT ANALYSIS

The general equilibrium approach is an established analytical framework for evaluating the economic implications of policy intervention on resource allocation and incomes of agents. Its main virtue is the micro-consistent representation of the direct effects as well as indirect feed-backs and spillovers induced by exogenous policy changes. The simultaneous explanation of the origin and spending of the agents' income makes it possible to address both economy-wide efficiency as well as equity impacts of policy interference.

Theoretical general equilibrium analysis provides important qualitative insights into the driving forces of adjustment reactions by economic agents to exogenous policy constraints. However, its contribution to actual policy analysis remains limited. The reason is that theoretical models are highly stylized to keep analytical tractability. As soon as certain real-world complexities are taken into account, e.g. a more detailed production structure, analytical solutions are no longer available and numerical solutions methods are required. In this context, computable general equilibrium (CGE) models have become the standard tool for applied analysis of measures in various policy domains.[24] These models incorporate lots of details and come up with concrete numbers on policy-induced economic and environmental effects. Moreover, CGE models provide an open framework for the incorporation of new economic research strings such as the new growth and trade theory or important relationships to other disciplines adopting an integrated assessment approach (see Conrad 1999, 2001 for surveys on recent developments). This flexibility makes CGE models a central methodological tool for sustainable impact analysis.

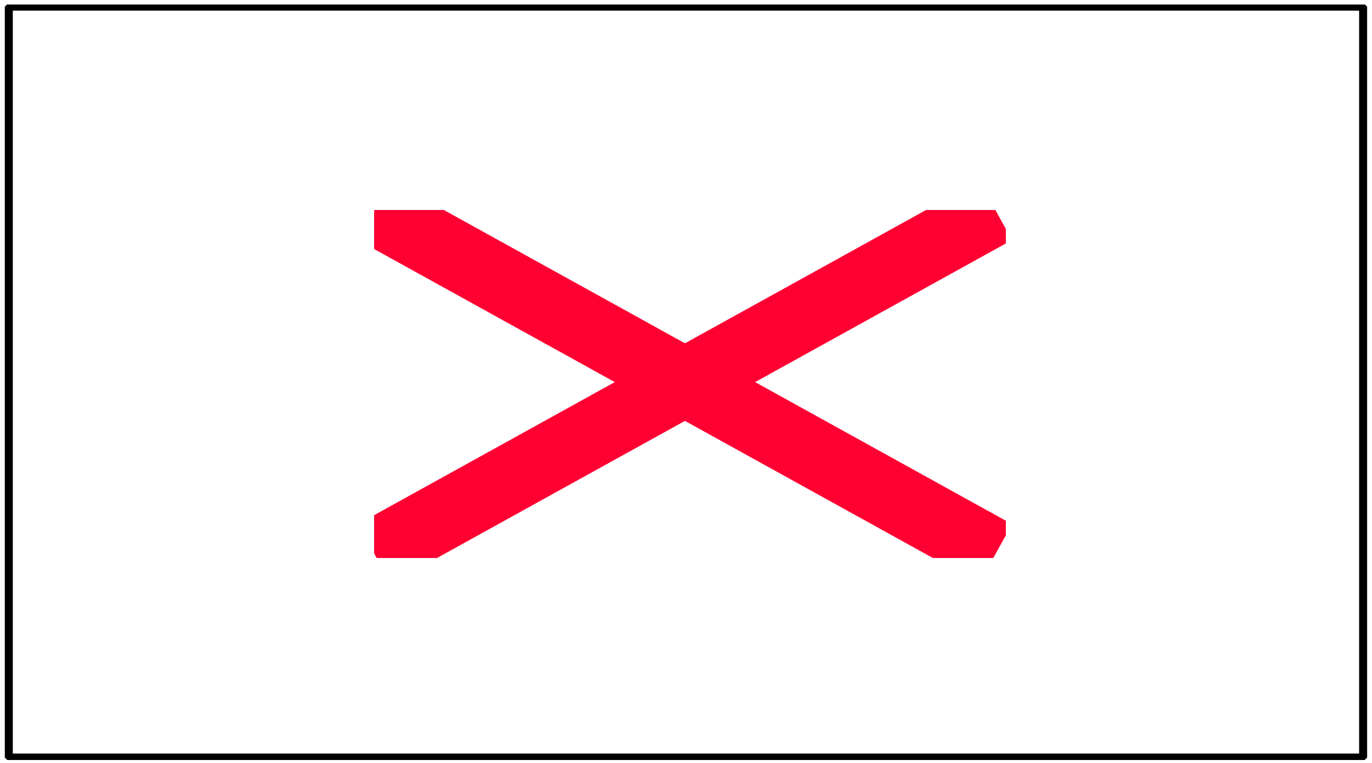
Ultimately, sustainability impact analysis requires a global and intertemporal perspective. Not only is there a need of assessing policy impacts across regions but also across generations. An intertemporal, multi-region perspective is state-of-the-art in applied CGE analysis; there are also various examples of models with overlapping generations (OLG). However, an OLG framework with multiple regions and sectors still poses considerable computational challenge and requires severe tradeoffs with the level of details that can be captured in the model.

Without loss of generality, this paper focuses on standard multi-region, multi-trade CGE models of global trade and energy use which are meanwhile employed by many international institutions, research centers, universities and consultancies. One prominent example is the GEM-E3 model system (see e.g. Capros et al. 1999) that has been developed and applied since the early 90ies under the auspices of the European Commission.

Figure 1 provides a diagrammatic structure of a standard (one-period) model as often used for comparative-static analysis of trade and environmental policies. Primary factors of region *r* include labor $\overline{L}_r$, capital $\overline{K}_r$ and resources $\overline{Q}_{ff,r}$ of fossil fuels *ff* (crude oil, coal, and gas). A specific resource is used in the production of crude oil, coal and gas, resulting in upward sloping supply schedules.

[24] See e.g. Shoven und Whalley (1984, 1992), Piggot und Whalley (1985), Borges (1986), Pereira und Shoven (1988), Bergman (1990), Kehoe und Kehoe (1994), Klepper et al. (1995), and Bhattacharyya (1996).

Figure 1: Diagrammatic model structure



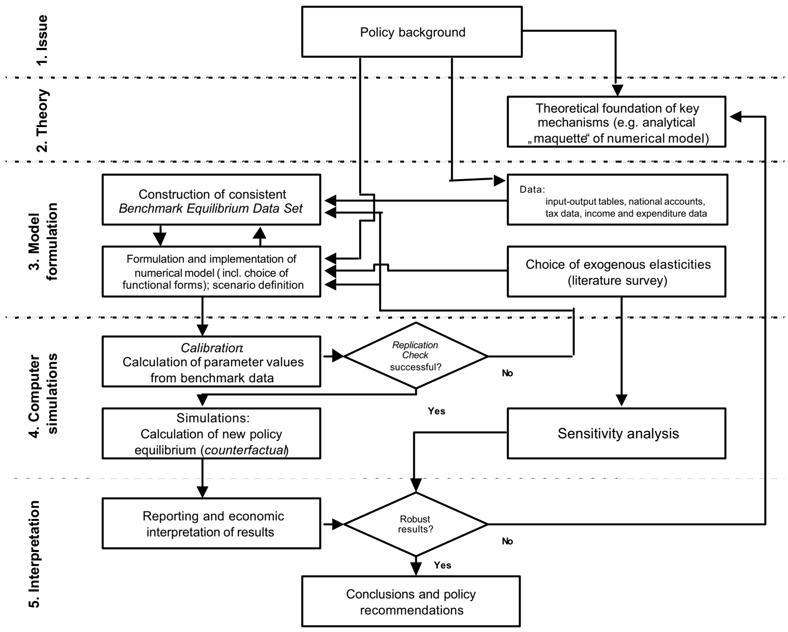
Production Y_{ir} of commodities i in region r, other than primary fossil fuels, is captured by aggregate production functions which characterize technology through substitution possibilities between various inputs.[25] Nested constant elasticity of substitution (CES) cost functions with several levels are employed to specify the KLEM substitution possibilities in domestic production between capital (K), labor (L), energy (E) and non-energy intermediate inputs, i.e. material (M). Final demand C_r in each region is determined by a representative agent RA_r, who maximizes utility subject to a budget constraint. Total income of the representative agent consists of factor income and transfers. Final demand of the representative agent is given as a CES composite which combines consumption of an energy aggregate with a non-energy consumption bundle. The substitution patterns within the non-energy consumption bundle as well as the energy aggregate are described by nested CES functions. All goods used on the domestic market in intermediate and final demand correspond to a CES composite A_{ir} of the domestically produced variety and a CES import aggregate M_{ir} of the same variety from the other regions (the so-called Armington good). Domestic production either enters the formation of the Armington good or is exported to satisfy the import demand of other regions. A governmental sector collects taxes (e.g. production taxes or subsidies *ty*, intermediate taxes *ti*, consumption taxes *tc*, tariffs *tm* and *tx*, or environmental taxes such as differentiated carbon taxes $t_i^{CO_2}$ and $t_C^{CO_2}$ on industrial and final fossil fuel use) which are used to finance the public good provision and public transfers.

The five main steps involved in constructing and using applied models are summarized in Figure 2. Initially, the policy issue must be carefully studied to decide on the appropriate model design as well as the required data. The second step involves the use of economic theory (at best, the draft of a simple analytical maquette model) in order to lay out key economic mechanisms that drive the results in the more complex numerical model. Data work, model formulation and implementation then delivers the framework for numerical policy analysis. This step also involves the set-up of alternative policy instruments and strategies that induce changes vis-à-vis the reference situation (scenario definition). In determining results of policy simulation, the choice and parameterization of functional forms are crucial. The procedure most commonly used to select parameter values is known as calibration (see Mansur and Whalley 1984). Calibration of the free parameters of functional forms requires a consistent one year's data (or a single observation represented as an average over a number of years), together with exogenous elasticities that are usually taken from literature surveys.[26]

[25] In Figure 1, which is linked to the concrete policy application in section 2.1, the non fossil-fuel commodities include an energy-intensive aggregate *EIS*, electricity generation *ELE*, and *Other Sectors*.

[26] Benchmark data is typically delivered in value terms. In order to obtain separate price and quantity observations, the common convenient procedure is to choose units for goods and factors so that they have a price of unity in the benchmark equilibrium.

Figure 2: Steps in computable general equilibrium analysis



The calibration is a deterministic procedure and does not allow for statistical test of the model specification. The one consistency check that must necessarily hold before one can proceed with policy analysis is the replication of the initial benchmark: the calibrated model must be capable of generating the base-year (benchmark) equilibrium as a model solution without computational work. Within the policy simulations single parameters or exogenous variables are changed and a new (counterfactual) equilibrium is computed. Comparison of the counterfactual and the benchmark equilibrium then provides information on the policy-induced changes of economic variables such as employment, production, consumption, relative prices, etc. Finally, the model results must be interpreted based on sound economic theory. Due to the reliance on exogenous elasticity values and a single base-year observation, comprehensive sensitivity analysis on key elasticities (and possibly alternative assumptions on economic incentives) should be performed before concrete policy recommendations are derived.

All in all, the typical CGE approach to policy analysis can be understood as theory with numbers, where a theoretical model is calibrated to observed statistics and then used for policy simulations.

Table 1 provides a selection of typical indicators in standard CGE models of global trade and energy use that could be used for quantitative tradeoff analysis along the three dimension of sustainability.

Table 1: Sustainability themes and model indicators

Sustainability themes	Examples of possible core indicators in CGE models
Economic aspects	
Economic development and growth	GDP (GDP per capita)
Produced assets	Net savings
Social aspects	
Employment	Unemployment rate
Income	Household final consumption expenditure
Environmental aspects	
Air quality	Intensity / Total of SO_x and NO_x emissions
Climate change	Intensity / Total of CO_2 emissions

2. METHODOLOCIGAL EXTENSIONS

Compared to analytical models, the numerical approach accommodates the analysis of complex economic interactions and the impact assessment of structural policy changes. However, this advantage can easily turn into a disadvantage when simulation results come as black box and are not explained on the basis of rigorous economic theory. Often, the interpretation of general equilibrium effects as the total of several partial equilibrium effects is difficult, particularly if the latter can work in opposite directions. Therefore, one challenge of general equilibrium modeling is to provide decomposition methods that facilitate the isolated investigation of various partial effects contributing to the total policy impact. Section 2.1. presents two alternative decomposition techniques that can be very helpful in diagnosing the channels through which international trade transmit policy impacts between countries.

Another important extension to the standard CGE framework is the specification of optimal policy problems. This renders a *M*athematical *P*rogram with *E*quilibrium *C*onstraints (MPEC), a new class of mathematical programs introduced by Luo, Pang and Ralph (1996). The MPEC problem class permits a formal characterization of instrument design within which the objective function depends on the instrument (e.g. tax rates), i.e. policy variables that are exogenously specified in a conventional application. With respect to *sustainable* policy making, the MPEC framework allows to address central questions such as "what is the optimal tax policy to maximize economic performance given minimum constraints on the level of environmental quality or distributional concerns". Section 2.2 illustrates the use of MPECs.

Due to lack in data, CGE models are typically not econometrically estimated, but calibrated to a single benchmark equilibrium. Apart from the benchmark statistics and assumptions about the incentives of economic agents, the effects of policy interference then depend crucially on the choice of values adopted for elasticities. Extensive sensitivity analysis must be performed to test the robustness of "central case" model results before any firm policy conclusions can be drawn. In this context, section 2.3 illustrates a systematic approach to sensitivity analysis.

The techniques described in Sections 2.1 through 2.3 are generic. Applications so far have focused on the analysis of multilateral greenhouse gas abatement policies and induced trade effects. Yet, application to other fields, e.g. trade policy analysis and induced environmental effects, is straightforward.

2.1. Decomposition technique

Policy interventions in large open economies do not only affect the allocation of domestic resources but also change international market prices. The change in international prices implies an indirect (*secondary*) effect for *all* trading countries. This secondary terms-of-trade effect may have important policy implications. For example, international environmental agreements should account for induced changes in terms of trade when searching for "equitable" burden sharing schemes. Section 2.1.1 presents a decomposition that splits the total effect or policy changes on individual countries into a *domestic market effect* holding international prices constant and an *international market effect* as a result of changes in international prices. Splitting the total effect into these components conveys important economic information as to why a country will benefit or lose from adjustments in domestic and international markets.

In applied policy analysis, it is often relevant to link changes in endogenous variables (e.g. regions' welfare or emissions) to changes in the policy instruments (e.g. tariff rates). Such a decomposition of the total policy effect could, for example, be used to evaluate induced gains or losses from multilateral trade liberalization at the bilateral level and set up transfer or compensation systems. Section 2.1.2 describes a decomposition technique (originated by Harrison at al. 2000) to measure bilateral spillovers from policy interference.

In order to highlight the relevance of the decomposition techniques for sustainable impact analysis, sections 2.1.1 and 2.1.2 provide an application to climate change policy. The numerical simulations refer to a situation where industrialized countries apply domestic carbon taxes to meet their emission targets under the Kyoto Protocol (UNFCCC 1997).

2.1.1. Decomposing international spillovers

The effects of policy intervention in large open economies can be broken down into a *domestic market effect*, assuming that international prices remain constant, and an *international market effect* as a result of changes in international prices. The key idea with respect to applied model analysis is that each region of a multi-region trade model (MRT) can be represented as a small open economy (SOE) in order to separate the domestic policy effect under fixed terms of trade. Policy induced changes in international prices from the multi-region model can then be imposed parametrically on the small open economy to measure the international market effect commodity by commodity (Böhringer and Rutherford 2002a).

Figure 3 illustrates the steps involved in the decomposition procedure. Computation of the domestic market effect simply requires to keep international prices at the benchmark (reference) level and then impose the domestic policy change on the specific country.

Hence, for the intermediate SOE equilibrium calculation (A→B), changes on the domestic market have no effect on international prices. The spillover effect for any economic or environmental activity of a specific country is then simply the residual between the SOE equilibrium solution at benchmark terms-of-trade and the full MRT solution for the specific country (C).[27]

Figure 3: The MRT-SOE decomposition

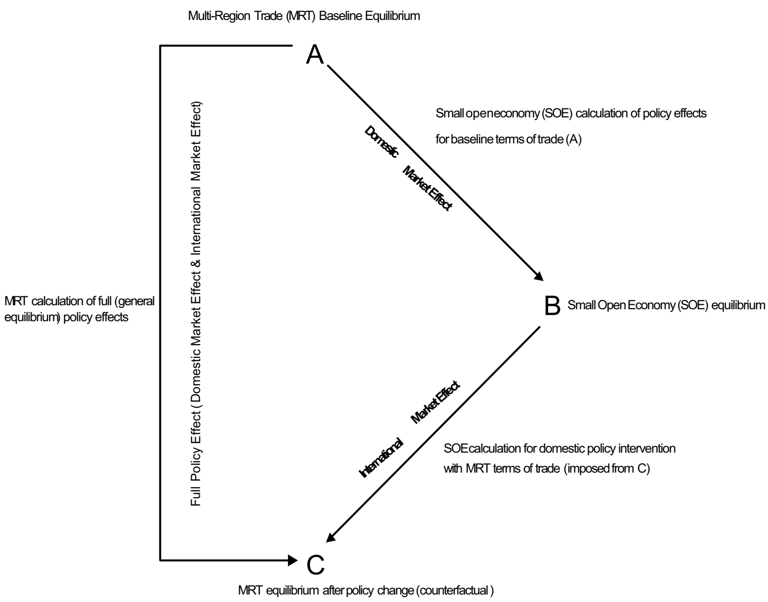


Table 2 summarizes results for the decomposition of economic effects induced by carbon abatement policies of industrialized countries under the Kyoto Protocol. The column *Total Policy Effect* reports aggregate consumption changes in % vis-à-vis the business-as-usual (BaU) that emerge from carbon taxes of industrialized countries to comply with their Kyoto emission reduction targets in 2010.

[27] A simple consistency check for the decomposition is as follows: Imposing the changes in international prices which are delivered by the MRT solution (A→C), one should be able to reproduce exactly the MRT solution from the SOE perspective (B→C).

Tax-induced reallocation of resources due to emission constraints (e.g. fuel shifting or energy savings) causes substantial adjustment costs for OECD countries. Furthermore, there are considerable international spillover effects from abating industrialized countries to non-abating countries: Adjustments on international markets induce welfare losses for FSU as well as MPC and, to a much smaller extent, for ROW. All other non-abating countries benefit to varying degrees from the changes in international prices associated with emission abatement in OECD countries.

Application of the decomposition method allows to gain insights into the different sources of welfare changes across regions. Table 2 lays out how the economic impact of carbon taxes turns from the domestic market effect into the total policy effect as changes in international prices are successively imposed upon the SOE sub-models. The column *International Spillovers* indicates the magnitude of international spillovers measured in percent of the total policy effect. Obviously, the international spillovers is identical to the total policy effect for those countries which do not undertake domestic abatement, i.e. countries whose domestic market effect is zero. As to abating countries, the decomposition provides information on the sign and relative magnitude of the primary domestic and the secondary international impacts. International spillovers are negative for USA, CAN and OOE, whereas CEA, EUR, and JPN benefit from the adjustments on international markets.

Regarding international spillovers, most important are the adjustments on international coal and crude oil markets (see column *Fossil Fuel Market Effect*). The cutback in demands for fossil fuels from abating OECD countries depresses the international prices for oil and coal. As a consequence, countries which are net importers of coal and crude oil gain, whereas net exporting countries lose. For CAN, MPC, and ROW, which are net exporters of both coal and crude oil, the aggregate welfare effect is unambiguously negative. Likewise, net importers EUR, JPN, CHN, IND, BRA and ASI experience welfare gains. For countries which are net importer of one fossil fuel *and* net exporter of the other, the aggregate effect depends on export and import quantities as well as the relative changes in international coal and crude oil prices.

The next step of decomposition accounts for international price changes in non-energy markets where traded goods are differentiated by region of origin. On these markets, developing countries typically face adverse spillover effects. Apart from higher export prices of developed countries, developing countries suffer from a scale effect as economic activity and hence import demand by developed countries decline. On the other hand, this effect can be (partially) offset by an opposite substitution effect. Developing countries gain market shares in Annex B countries because their exports become more competitive. The same mechanisms apply to trade between abating countries with large differences in imposed carbon taxes. As an example, OOE, which has low carbon taxes, suffers from increased export prices of trading partners with high carbon taxes, such as Japan.

Table 2: Decomposition of total consumption changes for carbon tax case (*NTR*)

	Domestic Market Effect (in % of BaU consumption)	Fossil Fuel Market Effect** (in % of BaU consumption)	Total Policy Effect (in % of BaU consumption)	International Spillovers* (in % of Total Policy Effect)	Carbon Tax (in USD_{95} / ton C)	Emission Reduction (in % vs. BaU)
CAN	-0.69	-0.86	-0.88	21	230	28
CEA	0.00	0.26	0.29	100	1	-6
EUR	-0.14	-0.06	-0.06	- 116	107	14
FSU	0.00	-0.43	-1.03	100	-	-48
JPN	-0.44	-0.38	-0.30	-47	300	26
OOE	-0.13	-0.47	-0.65	81	76	16
USA	-0.36	-0.38	-0.40	9	160	27
ASI	0.00	0.26	0.14	100	-	-
BRA	0.00	0.08	0.09	100	-	-
CHN	0.00	0.26	0.20	100	-	-
IND	0.00	0.32	0.27	100	-	-
MPC	0.00	-0.77	-0.99	100	-	-
ROW	0.00	-0.05	-0.08	100	-	-

Key: CAN - Canada, CEA - Central European Associates, EUR - Europe (EU15 and EFTA), FSU - Former Soviet Union (Russian Federation and Ukraine), JPN - Japan, OOE - Other OECD (Australia and New Zealand), USA - United States, ASI - Other Asia (except for China and India), BRA - Brazil, CHN - China (incl. Hong Kong and Taiwan), IND - India, MPC - Mexico and OPEC, ROW - Rest of World

* Calculated as: 100* [(Total Policy Effect) - (Domestic Market Effect)] / (Total Policy Effect)

** Accounting for domestic market effect and international price changes for crude oil and coal

To sum up: Application of the decomposition method to emission regulation under the Kyoto Protocol reveals that among signatory countries, Australia, Canada, New Zealand and USA bear a secondary burden through changes in international terms of trade, whereas Europe and Japan experience secondary benefits. Most developing countries gain a comparative advantage due to abatement in Annex B regions, but fossil fuel exporters such as Mexico and OPEC are seriously hurt. A major determinant for the differences in sign and magnitude of spillovers is the trade position of countries on international coal and crude oil markets: Depressed international prices for fossil fuels, that are due to the cutback in global fossil energy demand, provide gains for fossil fuel importers and losses for fossil fuel exporters.

2.1.2. Decomposing bilateral spillovers

Harrison, Horridge, and Pearson (HHP) propose a generic linear decomposition methodology for calculating the contributions of multiple exogenous policy instruments to the resulting changes in individual endogenous variables (Harrison et al. 200). The HHP method can be explained along a simplified example in which an *endogenous* variable Z is expressed as an explicit function of a vector of *exogenous* variables $\overrightarrow{X}$ (the policy instruments):

$$Z = F(\overrightarrow{X}) = F(x_1, x_2, \ldots, x_n) \, .$$

A change in the exogenous policy instruments $\overrightarrow{X}$ induces an endogenous change ΔZ in Z. For policy analysis, it is often useful to attribute changes in the endogenous variable to changes in the policy instruments. One way of decomposing the total change ΔZ in the endogenous variable with respect to the individual contributions from exogenous variables would be a sequential approximation of the impacts of *one* exogenous variable while keeping *all others* constant. Assuming that *F* is differentiable, the contribution of a change in the *i*-th exogenous variable to ΔZ (as x_i moves from the initial value x_i^0 to the new value x_i^1) can then be computed as the line integral:

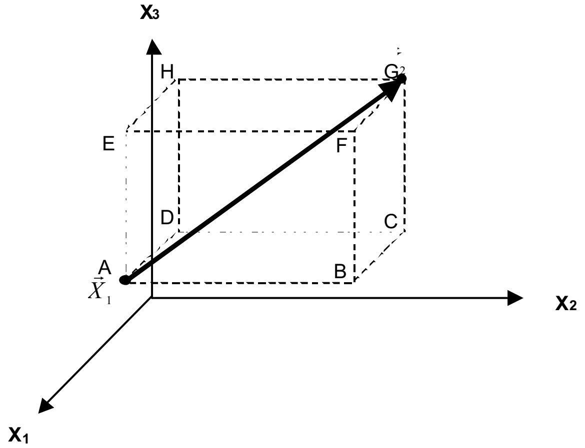
$$\Delta Z\big|_{x_i} = \int_{x_i^0}^{x_i^1} \frac{\partial F}{\partial x_i} dx_i \, .$$

For the numerical computation, the total change in the exogenous variable Δx_i is divided into sufficiently small steps to approximate the line integral through linearization.

When *F* is nonlinear, the total change from shocks in exogenous variables can not be decomposed in additive line-integrals for each exogenous variable starting from the initial value Z^0. The impact of a change in an exogenous variable must be calculated, taking into account the contributions of *previous* changes in other exogenous variables. This implies that the decomposition is potentially sensitive to the sequential ordering of changes in the exogenous policy variables. As there are *n!* ways of sequential ordering of *n* exogenous variables, one quickly ends up with a large number of (possibly) different decompositions for relatively small-scale policy experiments. For many policy packages (including multilateral emission abatement contracts, such as the Kyoto Protocol) no one sequential decomposition might be obviously more plausible than any other. HHP therefore suggest an order-independent "natural " way of calculating contributions. On the "natural" path, the exogenous variables move *together at the same rate* towards their final value along a straight line between their starting values $\overrightarrow{X}^0$ and the final values $\overrightarrow{X}^1$. The straight line between these points is obtained by changing the elements of $\overrightarrow{X}$ as a differentiable function *H* of some parameter *t* holding the rate of change in the exogenous variables constant along the path (where $\overrightarrow{X}^0 = H(t = t^0), \overrightarrow{X}^1 = H(t = t^1)$).

Figure 4 illustrates the difference between the sequential method of decomposition and the HHP approach. In contrast to moving along the *edges* of the policy cube, the HPP method follows a straight line between the pre- and post-simulation values.

Figure 4: Sequential ordering versus "natural "path



For n exogenous variables, the total change in the endogenous variable is equal to:

$$\Delta Z = \sum_{i=1}^{n} \int_{t=t^0}^{t=t^1} \frac{\partial F}{\partial x_i} \frac{dx_i}{dt} dt$$

This concept is easily generalized to the case where the relationship between exogenous and endogenous variables is implicit, which is typically the case for computable general equilibrium models used for the economic analysis. As HHP point out, it is possible to calculate numerical values for the gradients $\frac{\partial F}{\partial x_i} \frac{dx_i}{dt}$ at all points of the "natural" path by solving a system of linear equations. The individual contributions of changes in policy instruments x_i can then be approximated through linearization of the respective line integral which involves solving a system of linear equations R times, where R renders a sufficiently small step-size $\Delta t / R$ (with $\Delta t = t^1 - t^0$).

Application of the HHP decomposition to climate change policies provides concrete estimates for bilateral spillovers that might be useful for the delicate policy issue of who should pay for adverse international spillovers to developing countries (Böhringer and Rutherford 2002b).[28] The HHP procedure avoids arbitrariness in the calculation of spillovers as compared to any sequential ordering of abatement policies in industrialized countries.

[28] The United Nations Framework Convention on Climate Change (UNFCC 1992) guarantees compensation from industrialized countries to the developing world for adverse spillovers from emission abatement in the industrialized world (Articles 4.8 and 4.9).

The results, presented in Table 3, show the percentage of the welfare cost for each region (rows) attributable to carbon taxes in each of the industrialized regions (columns). These numbers are obtained by evaluating a line integral where the carbon *taxes* across abating regions are change at equal rates starting from zero and ending with the final carbon taxes as reported in Table 2.

Matrix elements with negative signs indicate that the effect of the abatement policy by the column region is opposite to the sign of the total welfare change for the row region. For example, the value of – 30 at the intersection of *row* ASI with *column* JPN means that abatement actions in JPN induce a welfare *loss* in ASI (since overall the welfare impacts for ASI are positive).

Table 3: Decomposition of consumption impacts from carbon taxes at the bilateral level

	Consumption change		Percentage of the welfare cost for each region (rows) attributable to carbon taxes in each of the Annex B regions (columns)				
	in % vs. BaU	in bn USD_{95}	CAN	EUR	JPN	OOE	USA
CAN	-0.88	-0.62	87	6	4		2
CEA	0.29	0.10	11	24	18	1	47
EUR	-0.06	-0.69	-15	250	-25	-4	-105
FSU	-1.03	-0.51	3	40	4		52
JPN	-0.30	-1.65	-6	-12	148	-1	-29
OOE	-0.65	-0.33	3	13	12	33	39
USA	-0.40	-3.60	2	-4	-5	-1	107
ASI	0.14	0.24	12	19	-30	2	96
BRA	0.09	0.14	11	14	20	2	53
CHN	0.20	0.43	7	18	15	2	59
IND	0.27	0.16	7	17	15	2	59
MPC	-0.99	-1.71	9	19	20	1	51
ROW	-0.08	-0.19	15	31	51	6	-3
Total	-0.22	-8.23					

Matrix elements with positive signs denote that the impact of the abatement policy in the column region on the row region has the same sign as the total welfare impact of the row region. For example, a positive *row* entry for MPC, which in total is negatively affected by abatement in industrialized countries, reveals that action of the respective column region produces negative welfare spillovers. The diagonal elements for abating regions reveal the percentage of their aggregate welfare changes due to their own policy. The *own-policy* effect dominates the aggregate of the *foreign-policy* effects, except for OOE and, in particular, for CEA, which impose rather small domestic carbon taxes.

Reading down the *column* USA in Table 3, we find that abatement actions by the USA produce by far the largest spillovers to other countries. The main source for these spillovers are larger adjustments on the international fossil fuel markets due to the substantial cutbacks in US fossil energy demands. Emission constraints in the USA account for the bigger part of the decline in fossil fuel producer prices following multilateral abatement under the Kyoto Protocol. This produces positive bilateral spillovers to fuel importers, such as EUR, JPN and developing regions ASI, BRA, CHN, as well as IND. Fuel exporters, such as CAN, MPC or ROW, are negatively affected. At the other end of the impact spectrum, we find OOE and CEA, whose spillovers to other regions are rather negligible due to their moderate tax rates and small shares in overall trade volumes. Reading Table 3 by rows, we obtain information on how a country is affected by the carbon taxes of abating industrialized countries.

The percentage changes in welfare from individual policy action as reported in Table 4 can be translated into monetary units. Table 4 presents the matrix of compensating (net) transfer payments that must be assigned on a bilateral basis in order to provide compensation for spillovers from abatement policies in individual industrialized countries. A negative entry indicates compensation claims of the *row* region towards the *column* region.

Table 4: Compensating transfers from region (rows) to region (columns) in billion dollars, annually between 2008 and 2012

	CAN	CEA	EUR	FSU	JPN	OOE	USA
CEA	0.01						
EUR	0.14	-0.02					
FSU	-0.02		-0.2				
JPN	0.12	-0.02	0.03	0.02			
OOE	-0.01		-0.07		-0.06		
USA	-0.06	-0.05	-0.58	0.27	-0.3	0.17	
ASI	0.03		0.05		-0.07		0.23
BRA	0.02		0.02		0.03		0.07
CHN	0.03		0.08		0.06	0.01	0.25
IND	0.01		0.03		0.02		0.1
MPC	-0.15		-0.32		-0.34	-0.02	-0.87
ROW	-0.03		-0.06		-0.1	-0.01	0.01

Tables 3 and 4 reveal fundamental problems underlying the issue of compensation to developing countries for induced economic costs. A developing region may benefit from abatement in one industrialized country, but suffer from abatement in other industrialized regions. This raises the question of whether developing countries that are compensated for adverse spillovers on the one hand should pay for positive spillovers on the other hand. To put it differently, industrialized countries that compensate for adverse spillovers to some developing countries may well claim transfers from those developing countries which benefit from their abatement policy.

2.2. The MPEC framework

A relatively new research area in applied general equilibrium analysis is based on *M*athematical *P*rograms with *E*quilibrium *C*onstraints (MPEC), a new class of mathematical programs introduced by Luo, Pang and Ralph (1996). The MPEC problem class permits a formal characterization of optimal policies within which the objective function depends on policy variables (e.g. tax rates – see example below) that would be exogenously specified in a conventional CGE application. This opens up a variety of policy applications in the field of sustainable impact analysis.

In formal terms, the optimal policy problems in CGE models can be expressed as a specific case of the general MPEC formulation:

$$\max_t \; f(z;t)$$

s.t. z solves the equilibrium constraints *F(z;t)*

where:

t ? $\mathbf{R}^m$ is a vector of policy (instrument) variables which are the choice variables for the problem,

z ? $\mathbf{R}^n$ is a vector of endogenous variables that is determined by the equilibrium problem, i.e. $z = \begin{pmatrix} p \\ y \end{pmatrix}$, where *p* are prices and *y* are activity levels,

F(z; t) is a system of equations which represents market equilibrium conditions, and

f : $\mathbf{R}^{n+m}$? $\mathbf{R}^1$ is the objective function.

Böhringer and Rutherford (2002c) provide a large-scale MPEC application to design optimal carbon tax programs in a static multi-region, multi-sector general equilibrium model of global trade and energy use. In their case, the constraints *F(z; t)* describe the equilibrium conditions of a standard multi-sector, multi-region computable general equilibrium (CGE) model of global trade and energy use. *F(z; t)* includes an emission reduction constraint for an open economy that can be achieved through the use of (endogenous) emission taxes. The taxes correspond to the set of choice variables *t* in the optimal taxation problem and can be differentiated across different segments of the economy to maximize an objective such as overall real consumption. Böhringer and Rutherford (2002c) use the optimal tax framework to assess the relative importance of four alternative arguments that might justify the common policy practice of environmental tax differentiation: initial tax distortions, distributional concerns, leakage motives or international market power. Simulation results for the European and U.S. economies conclude that there is little economic rationale for the common policy practice to discriminate strongly in favor of heavy industries. Among the four motives for tax differentiation examined, only very specific concerns about job layoffs give reasons for tax exemptions to energy-intensive industries. Concerns about global environmental effectiveness provide some justification for tax discrimination in favor of energy- and export-intensive industries although leakage must be very high to make the case for substantial tax reductions. Tax interaction with initial fiscal energy taxes, broader-ranged concerns about factor incomes, as well as strategic international tax burden shifting can hardly rationalize the current practice in OECD countries to have only very low environmental taxes on energy-intensive industries or even exempt them.

2.3. Systematic sensitivity analysis

A wide-spread criticism to CGE analysis is the deterministic calibration approach to specify parameters of functional forms. Clearly, a stochastic estimation of parameters would be preferable. However, a (complete) econometric estimation of large-scale general equilibrium systems is typically doomed to failure due to severe data problems. The simultaneous estimation of all parameters would either require unrealistically large numbers of observations or overly severe identifying restrictions. The pragmatic way is to stick with the calibration approach and to check the sensitivity of central model results with respect to uncertainties in the elasticity space.

One approach to systematic sensitivity analysis is to conduct Monte Carlo simulations where values for key elasticties (e.g. trade elasticities, energy demand elasticities and fossil fuel supply elasticities) are drawn from uniform probability distributions around the model central values. Table 5 provides an illustrative statistical summary of results for CGE policy simulations on the economic effects of the Kyoto Protocol (see Böhringer and Vogt 2003). The summary includes the core (central case) values together with the mean and the median as well as the 5 % quantile and 95 % quantile. Such statistics provide useful insights into the robustness of model results.

CONCLUSION

Computable general equilibrium (CGE) models provide a flexible tool for sustainable impact assessment. These models can incorporate lots of sustainability (meta-)indicators in a single consistent framework and allow for a systematic quantitative tradeoff analysis along the three dimension of sustainability. Decomposition methods can be employed to better understand the complex adjustment mechanisms triggered by exogenous policy changes. The decomposition of general equilibrium results may also deliver valuable information for the proper design of policies. Furthermore, recent computational developments permit the formulation of optimal policy problems within large-scale CGE models. This class of models then can help to determine *optimal* policy choices for sustainable development.

Table 5: Results of Monte Carlo simulations on Kyoto Protocol (Böhringer and Vogt 2002)

Scenario:	*Implementation of Kyoto by domestic carbon taxes of industrialized countries*				
	core value	mean	median	5% quantile	95% quantile
	Consumption change in % vs. BaU				
OOE	-1.18	-1.16	-1.14	-1.38	-1.01
CAN	-1.48	-1.43	-1.42	-1.59	-1.31
EUR	-0.17	-0.19	-0.20	-0.23	-0.14
JPN	-0.26	-0.31	-0.31	-0.38	-0.21
CEA	0.49	0.50	0.50	0.29	0.73
FSU	-0.93	-0.88	-0.87	-1.04	-0.74
USA	-0.51	-0.56	-0.53	-0.78	-0.42
ROW	-0.35	-0.31	-0.30	-0.42	-0.24
TOTAL	-0.24	-0.25	-0.25	-0.31	-0.21
	Marginal abatement costs in USD97 per ton of carbon				
OOE	126	135	124	92	207
CAN	145	154	145	112	222
EUR	111	114	110	88	149
JPN	183	191	181	139	270
CEA	0	0	0	0	0
FSU	0	0	0	0	0
USA	156	170	156	114	271
	Consumption change in USD97 per capita				
OOE	-114	-113	-110	-134	-99
CAN	-162	-155	-153	-174	-141
EUR	-23	-25	-26	-31	-18
JPN	-53	-61	-61	-76	-43
CEA	8	8	8	5	12
FSU	-12	-11	-11	-13	-9
USA	-92	-102	-96	-142	-76
	Emission reduction in % vs. BaU				
TOTAL	9.60	9.51	9.50	9.00	10.00

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THE IMPACT OF TRADE LIBERALISATION ON THE ENVIRONMENTAL SUSTAINABILITY OF AGRICULTURE IN THE EU ACCESSION COUNTRIES

Luiza Toma

SUMMARY

This paper analyses the linkages between the environment and agricultural trade, focusing on the case of the Central and Eastern European Countries (CEECs), in the process of their accession to the European Union (EU).

There has been a strong movement towards increased linkage between international trade and the environment in the EU, as the distinction between purely domestic and international policy has gradually eroded. This view applies consequently to the CEECs' trade relationships with the EU.

The CEECs have been affected by two types of distortions: agricultural trade policy and environmental distortions. Trade distortions consist in taxing agricultural exports and protecting manufactures and agricultural import substitutes through import tariffs and/or quantitative restrictions on imports. Environmental distortions arise from the lack of the internalisation of the full social value of natural resources due to inadequate institutions and difficulties for implementing and enforcing policies that could off-set such institutional inefficiencies.

The structural adjustment programs implemented by the World Bank and the International Monetary Fund, together with the EU harmonisation process have significantly liberalised CEECs' trade regimes by gradually reducing export taxation, eliminating quantitative import restrictions and significantly reducing import tariffs. Nevertheless, adjustment programs and harmonisation process have dealt much less with the environmental distortions, which require a much more sophisticated governmental and legal system.

The gap which exists in the treatment of the two different types of distortions -trade and environment- raises a second-best problem: in a world of multiple distortions, it is not possible *a priori* to determine whether eliminating some of them will be welfare-increasing. Moreover, the elimination of the trade distortions has a theoretically ambiguous effect on the environment. Whether, in practice, agricultural trade liberalisation will positively or negatively affect the quality of the environment in the CEECs, cannot be ascertained before empirical analysis has been undertaken.

The models used in the 1990s to analyse the implications of trade liberalisation for an enlarged EU agricultural sector vary from using back-of-an-envelope calculations to computable general equilibrium models. There are few empirical attempts to measure the impact of agricultural trade liberalisation on the environment in the CEECs. Most of the EU enlargement models do not tackle the issue, mainly due to problems of data availability. Whereas data on trade between the CEECs, EU and third countries raises few availability issues, reliable environmental data is still missing much for most of the CEECs.

As partial and general equilibrium models are already popular in dealing with the EU enlargement, it might appear to be technically and financially easier to invest in environmental data collection needed to adjust these models so as to include the agri-environmental component rather than to apply other methodologies, available mostly at a theoretical level. Nevertheless, the selection of the most appropriate methodologies should be based on their being able to answer the questions posed to them. Simply adjusting existing models may be less accurate in dealing with the CEECs. Therefore new models should be created, as the costs related to data collection, as well as methodology creation and implementation would be lower than those implied by the inaccurate adjustment of existing, modelling approaches. Bearing in mind the diversity of environmental problems occurring in the CEECs, a mix of methodologies would be preferable to measure the environmental impact of agricultural trade liberalisation.

Applying methodologies to measure the impact of agricultural trade on the environment would provide policy-makers in the CEECs with better feedback on the impact of trade policies on agri-environmental issues.

ABSTRACT

This paper analyses the linkages between the environment and agricultural trade, focusing on the case of the Central and Eastern European countries (CEECs), in the process of their accession to the European Union (EU).

The paper begins with a brief picture of the linkages between agricultural trade and the environment. It then introduces the state-of-the-art analysis as regarding trade and environmental distortions in the CEECs, and discusses the methodologies applied to assess the impact of agricultural trade on the environment, in the case of the accession countries.

JEL Classification: F18; Q17; P29; Q01

Key Words : trade and environment linkages; agricultural trade liberalisation; environmental policies; EU enlargement; accession countries.

L'IMPACT DE LA LIBÉRALISATION DES ÉCHANGES SUR LA SOUTENABILITÉ ENVIRONNEMENTALE DE L'AGRICULTURE DES PAYS CANDIDATS À L'ADHÉSION À L'UNION EUROPÉENNE

RÉSUMÉ

Cet article analyse les liens entre environnement et commerce agricole, en se concentrant sur le cas des pays d'Europe centrale et orientale (PECO) en cours d'adhésion à l'Union européenne (UE).

Tandis que la distinction entre politiques proprement nationales et internationales s'effaçait graduellement, on a enregistré un effort important de l'Union européenne pour lier davantage commerce international et environnement dans l'Union Européenne. Cette vision doit donc aussi être appliquée aux relations commerciales entre les PECO et l'UE.

Les PECO ont souffert de politiques distorsives en matière de commerce agricole d'une part et en matière d'environnement d'autre part. Les distorsions d'origine commerciale sont engendrées par la taxation des exportations agricoles et la protection des produits manufacturés et des produits de substitution aux importations agricoles par des droits de douane et/ou des restrictions quantitatives aux importations. Au niveau de l'environnement, les distorsions résultent du défaut d'internalisation de la valeur sociale totale des ressources naturelles, dû à des institutions inadéquates et aux difficultés à mettre en œuvre et à faire respecter des politiques qui pourraient compenser l'effet des inefficacités institutionnelles.

Les programmes d'ajustement structurel mis en place par la Banque mondiale et le FMI, ainsi que le processus d'harmonisation vis-à-vis de l'Union européenne, ont permis de libéraliser de manière significative les régimes commerciaux des PECO en réduisant graduellement les taxes sur les exportations, en éliminant les restrictions quantitatives aux importations et en réduisant significativement les droits de douane sur les importations. Mais ces ajustements structurels et ce processus d'harmonisation ont eu beaucoup moins d'effets sur les distorsions environnementales, dont la correction nécessite un système étatique et légal beaucoup plus perfectionné.

La différence de traitement des deux sources de distorsions – le commerce et l'environnement – pose un problème de recherche d'optimum de second rang : dans un monde où les distorsions sont multiples, il n'est pas possible de déterminer a priori si l'élimination de certaines de ces distorsions sera source d'accroissement du bien-être. En outre, l'effet théorique de l'élimination des distorsions commerciales sur l'environnement est ambigu. En pratique, on ne peut pas déterminer si la libéralisation du commerce agricole affectera positivement ou négativement la qualité de l'environnement dans les PECO avant d'avoir entrepris une analyse empirique.

Les modèles utilisés dans les années 1990 pour analyser les implications d'une libéralisation commerciale sur l'Europe agricole élargie vont de calculs de coin de table à l'utilisation de modèles d'équilibre général calculable. Il y a eu peu de tentatives pour mesurer empiriquement l'impact d'une libéralisation du commerce agricole sur

l'environnement dans les PECO. La plupart des modèles portant sur l'élargissement de l'UE n'abordent pas ce problème, essentiellement par manque de données. Alors que les données de commerce entre les PECO, l'UE et les pays tiers posent peu de problèmes, des données fiables sur l'environnement manquent encore beaucoup pour la plupart des PECO.

Comme les modèles d'équilibre partiel et général sont déjà largement utilisés pour traiter de la question de l'élargissement, il peut sembler plus aisé techniquement et financièrement d'investir dans la collecte des données environnementales nécessaires pour adapter ces modèles de manière à y inclure la composante agro-environnementale, plutôt que de mettre en œuvre d'autres méthodes, qui ne sont définies, pour la plupart, qu'à un niveau théorique. Néanmoins, le choix des méthodologies les plus appropriées devrait se baser sur leur capacité à répondre aux questions qui leur sont posées. Utiliser simplement les modèles existants en les adaptant peut s'avérer moins juste pour répondre au cas des PECO. On devrait donc créer de nouveaux modèles, car les coûts de collecte de données, de création et de mise en œuvre d'une méthodologie seraient compensés par les bénéfices d'une approche plus juste que dans les modélisations existantes. Compte tenu de la diversité des problèmes environnementaux dans les PECO, il serait préférable d'utiliser conjointement plusieurs méthodes différentes pour mesurer l'impact sur l'environnement d'une libéralisation du commerce agricole.

L'utilisation de méthodes spécifiques pour la mesure de l'impact du commerce agricole sur l'environnement fournirait de plus aux décideurs politiques des pays de l'Est de meilleures informations concernant l'impact des politiques commerciales sur les problèmes agro-environnementaux.

RÉSUMÉ COURT

Cet article analyse les liens entre environnement et commerce agricole, en se concentrant sur le cas des pays d'Europe centrale et orientale (PECO) en cours d'adhésion à l'Union européenne (UE).

L'article commence par un exposé succinct des liens entre le commerce agricole et l'environnement. Il introduit ensuite l'état des recherches portant sur les distorsions commerciales et environnementales dans les PECO et passe en revue les méthodologies utilisées pour évaluer l'impact du commerce agricole sur l'environnement dans le cas des pays en voie d'adhésion.

Classification JEL : F18 ; Q17 ; P29 ; Q01

Mots-clefs : liens entre commerce et environnement ; libéralisation du commerce agricole ; politiques environnementales ; élargissement de l'union européenne ; pays en voie d'adhésion.

THE IMPACT OF TRADE LIBERALISATION ON THE ENVIRONMENTAL SUSTAINABILITY OF AGRICULTURE IN THE EU ACCESSION COUNTRIES[29]

Luiza Toma[30]

INTRODUCTION

This paper analyses the linkages between the environment and agricultural trade, focusing on the case of the Central and Eastern European Countries (CEECs), in the process of their accession to the European Union (EU).

Environmental policy framework in the CEECs has been defined based on a weak analytical background. There has been done very little in the field of environmental economics in the CEECs, due mainly to the fact that before 1989 data on pollution were kept confidential, and after that the main concern has been the development and modernisation of the environmental monitoring activity, and much less other issues (e.g. environmental performance of firms, cost-benefit analysis of introducing abatement pollution equipment, mechanisms of incentives and penalties). CEECs have started only during the last decade to adopt policy approaches towards sustainability based on the integration of the environment into sectoral policies and the reshaping of social and economic behaviour through the use of a broader range of instruments and by promoting the principle of shared responsibility. Environmental parameters, analytical methods and monitoring procedures need considerable improvement.

As associated countries, CEECs have paid increased attention to trade agreements with the EU. Still, the linkages between trade and the environment have only started to be considered by researchers and policy makers. The most tackled related issue has been the harmonisation of the part of *acquis communautaire* within agricultural sector that is closely linked with environment, mainly the *acquis* related to sanitary-veterinary, plant health, animal nutrition and agricultural markets legislation.

Analysing the relationship between environmental policies and agricultural trade might benefit the CEECs by increasing their competitiveness and enhancing their agreements with the EU on environmental and trade issues. The convergence of agri-environmental policies and the approximation of the agri-environment legislation are essential components of the integration of CEECs' markets into the European single market. The agri-environmental policies in the CEECs should be shaped based on their current framework, on the EU agri-

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environmental policy instruments, on the EU enlargement policy and the agricultural trade relationship between the CEECs and the EU.

The paper begins with a brief picture of the linkages between agricultural trade and the environment. It then introduces the state-of-the-art analysis as regarding trade and environmental distortions in the CEECs, and discusses the methodologies applied to assess the impact of agricultural trade on the environment, in the case of the accession countries.

1. LINKAGES BETWEEN AGRICULTURAL TRADE AND THE ENVIRONMENT

The relationship between international trade and environment has received increased attention in recent years, partly due to the stimulus of recent international negotiations on both environmental institutions and trade agreements.

In the past, the two issues, environment and trade have tended to be dealt with separately. Trade agreements, such as the General Agreement on Tariffs and Trade (GATT), dealt with trade issues, while environmental policy was dealt with either domestically (in the case of local pollution) or in separate multilateral environmental agreements (in the case of transboundary or global pollution). Many economists (such as Bhagwati and Srinivasan, 1997) have argued that this was both efficient and prudent. Efficiency follows from the policy targeting literature, which demonstrates that trade problems are best dealt with using trade policy instruments, and environmental problems with environmental policy instruments. And prudence follows from concerns that linkage may slow down trade negotiations or create new avenues through which special interest groups can block imports to protect their profits at the expense of consumers.

One of the earliest manifestations of trade and environment linkages was the introduction of environmental issues into the GATT (and later, World Trade Organisation, WTO) context since 1991. It was accepted that there was a need to examine the links between trade and environment and to establish appropriate procedures for this examination. Although trade considerations were predominant, one of the main aims was expected to help eliminate possible contradictions between trade policies and domestic, as well as international environmental policies, and make them mutually supportive.

A new era for the acknowledgement of the relationship between trade and environment started with the creation of the World Trade Organisation (WTO) in 1994. In the preamble of the new constitution, the Marrakech Agreement establishing the World Trade Organisation, an explicit link between the two issues has been made, stating sustainable development, environmental protection and conservation of scarce resources as explicit objectives and an integral part of the multilateral trading system. The WTO's Committee on Trade and Environment (CTE) has been established. Environmental concerns gained also more weight in the process of trade negotiations. At the 4th Ministerial Conference, which took place in Doha during November 2001, ministers adopted a declaration that includes several aspects of trade and environment. The commitment to the objective of sustainable development has been reaffirmed, pointing at the requirement that "the protection of the environment and the promotion of sustainable development can and must be mutually supportive" (Doha Ministerial Declaration). Moreover, within the work programme identified at Doha, the mutual supportiveness of trade and environment is emphasised as a key target and the CTE is given the task of pursuing the necessary work in order to have sustainable development appropriately reflected. However, concrete actions still have to be negotiated.

There has been a very strong movement towards increased linkage between international trade and environment in the EU as the distinction between purely domestic and international policy has gradually eroded. This view applies consequently to the CEECs trade relationships with the EU and carries an increasing weight.

European Commission (EC) opinion presented at WTO Meeting on Trade and Multilateral Environmental Agreements (2000) considers that unilateral measures to deal with global and transboundary environmental issues should be avoided. Trade measures can be an appropriate policy measure to use in multilateral environmental agreements (MEAs), when the international community has agreed to tackle and manage collectively international trade as a part of the environmental problem; when trade controls are required to make regulatory systems comprehensive in their coverage; to discourage free-riding which can often be a barrier to effective international co-operation; and to ensure compliance with the MEAs.

There are opinions against linking trade and environmental issues. Bhagwati (2000) makes the very important point that if there are "social" issues connected with trade liberalisation that require global co-ordination, then the solution may not be to burden the WTO ("burdening trade treaties and negotiations with social agendas"), but to reinforce the intergovernmental organisations set up to address these issues, United Nations Environment Programme (UNEP) amongst them. Comparing policy instruments to stones, he says that "trying to kill two birds with one stone is a recipe for missing both birds". He proposes "fashioning new stones", e.g. in the form of a possible World Environmental Organisation (WEO). Bhagwati's arguments against linkage are questioned in a number of ways. Few have difficulty with the proposition that local environmental problems should be addressed locally but, as Cooper (2000) points out, the problem lies with transboundary environmental externalities (spillovers) and the provision of international environmental public goods. For these issues the case against linkage is argued to be much less clear cut.

Other economists are advocating the trade-environment linkages. Repetto (2000) makes the point that where the first- best solution to these problems- targeted multilateral environmental agreements is not available, the second- best solution may not be to liberalise trade anyway. In these cases linkage can help. Xepapadeas (2000) notes that where countries are asymmetric in terms of their fundamentals there exist strong incentives not to cooperate, and considers whether trade policy can help with the design and enforcement of multilateral environmental agreements. He suggests that one way of dealing with this problem would be to connect multilateral trade and environmental negotiation. Zagonari (2000) goes further to indicate the conditions in which welfare will be enhanced by bringing environmental issues directly into trade negotiation.

There are two ways of analysing agricultural trade and environment policy linkages, as they both may impact on each other.

On one side, joint production of agricultural and environmental outputs means that agri-environmental policies aimed at internalising domestic externalities may affect quantities produced, trade flows and world prices and may impose burdens on trading partners. As regards to methodological work dealing with the environmental impact on agricultural trade, the environmental policy instruments with potential distorting effects on agricultural trade include *regulatory instruments* (such as product or process restrictions or bans, technical regulations, resource use quotas), *economic instruments* (such as environmental taxes and charges, environmental subsidies, deposit-refund systems) and *voluntary schemes* (such as eco- labelling schemes). As agri-environmental issues have only a recent history in the CEECs and they have only started to deal with internalising domestic externalities, there is little concern that CEECs' environmental policies might burden their trading relations.

On the other side, agricultural trade liberalisation has led to adjustments in production and consumption patterns and these changes may affect the environment. Agricultural production is dependent on the use of natural resources and modern agricultural systems rely on a wide range of industrial outputs such as fertilisers and pesticides that can affect environmental quality. Advocates of liberalisation asserted that environmental quality would improve as a side benefit. For example, some argued that the discipline of the market would cause farmers who formerly received crop subsidies to use less fertiliser, resulting in less water pollution. In contrast, critics of the agricultural trade liberalisation alleged that predominant reliance on market signals would cause environmental degradation. The abandonment of crop and livestock production on farmlands that provided biological and landscape values has been a frequently cited risk. These two opposite views appear to be competing hypotheses, but the outcomes are more complex and not mutually exclusive. There can be diverse environmental effects given the different trading regimes, agricultural systems, natural environments, and environmental management programs across countries.

The methodological work on environmental effects of agricultural trade introduces a taxonomy of the main types of national trade measures or instruments with potential impact on environment (OECD, 1993): *tariffs and related measures* (e.g., particularly when used as one instrument of a policy to protect domestic industries, tariffs can distort production and consumption away from environmentally-sustainable patterns); *non-tariff measures* (such as quotas, regulations, and standards that individually or in combination can distort trade patterns by protecting domestic industries with related environmental implications); *trade-related subsidies* (e.g., production subsidies that can support uncompetitive production on world markets leading to trade and environmental distortions in importing and exporting countries; export subsidies that can support the export of beneficial or harmful environmental technologies or goods); *trade-related intellectual property rights* (TRIPs) (that can modify trade in products that enhance or harm the environment and influence patterns of foreign investment and transfer of environmental technologies); *trade-related investment measures* (TRIMs) (that can affect the use or transfer of environmental products and technologies through foreign investment and the environmental performance of foreign firms).

The OECD (1993, 1999) and others (Runge et al, 1994, Abler and Shortle, 1998) have developed frameworks to decompose the effects of agricultural trade liberalisation on the environment into component parts: *scale effects* (changes in trade that expand national and world output can draw down the stock of environmental capital, ceteris paribus); *mix effects* (arising from changes in the mix of agricultural and non-agricultural goods produced and consumed, holding constant the scale of economic activity; if the products that increase after liberalisation have different environmental effects than those that decrease, environmental quality may change); *externalities feedback effects* (feedback effects on production or consumption of environmental externalities or other externalities induced by trade liberalisation, such as changes in fertiliser and pesticide use); *policy effects* (shifts in environmental policies induced by trade liberalisation; trade changes income or the environmental capital stock, either of which can induce changes in environmental or other policies) and *technology effects* (effects of trade on the environment caused by the development and adoption of new products, new production processes, or new pollution abatement technologies that cause both environmental benefits and costs).

Ervin (1999) makes a methodical taxonomy of methodologies used to estimate the environmental effects of agricultural trade liberalisation: *partial equilibrium models* (using econometric supply and demand functions for agricultural commodities to estimate changes in inputs, outputs, and prices); *general equilibrium models* (large- scale, static econometric models of the agricultural and non- agricultural sectors that incorporate the horizontal relationships between the sectors and the vertical relationships with input supply and processing, using input and output effects to infer environmental changes); *mathematical programming models* (static models of agricultural production and resource use for major regions or a nation that allocate resources based on satisfying an objective function (e. g., profit maximisation) subject to a set of constraints, such as amounts of land in various classes); *economic- environmental simulation models* (economic models are linked to environmental process models that estimate changes in loadings and ambient environmental conditions). Studies on agricultural trade effects on environment have been targeted at global, national, regional and local levels.

The choice of approach depends on the motivating research questions, the geographical setting, and often on available data. Empirical analyses of the agri-environmental changes that accompany trade liberalisation are restricted to those questions for which there is reliable data. For agriculture, that has meant that most attention has focused on changes in land cultivation, and shifts in fertiliser and pesticide use. However, when it is clear that shifts in production and trading patterns that derive from liberalisation will induce a broader range of environmental effects, additional analysis is necessary.

2. Effects of agricultural trade liberalisation on the environment in the EU accession countries

2.1. Agricultural trade and environmental distortions in the CEECs

Before 1990 and at the beginning of the transition period, the CEECs have been affected by two types of distortions: agricultural trade policy distortions and environmental distortions. Trade distortions consist in taxing agricultural exports and protecting manufactures and agricultural import substitutes through import tariffs and/or quantitative restrictions on imports. Environmental distortions arise from the lack of internalisation of the full social value of natural resources due to inadequate institutions and difficulties for implementing and enforcing policies that could off-set such institutional inefficiencies.

During the transition period, the CEECs have been in the process of significantly liberalising their trade regimes by gradually reducing export taxation, eliminating import quantitative restrictions and significantly reducing import tariffs. These reforms have been implemented mostly because of the pressures and financial support from international organisations in the context of broad-based programs of economic liberalisation usually referred to as "structural adjustment" (World Bank, International Monetary Fund) and due to membership application to the European Union.

The first step towards future EU enlargement involved the negotiation of Europe Agreements (EAs). They form the institutional framework for trade integration between the CEECs and the EU and govern economic aid and political co-operation between the EU and the applicant countries. The trade provisions of the EAs, called the Interim Agreements (IAs), have been implemented in each of the CEECs. The main objectives of these agreements are the creation of bilateral free trade areas for non-agricultural products within a period of ten years, providing also for some liberalisation of agricultural trade, close compatibility of economic laws and practice, and the development of a framework for political dialogue and economic co-operation. The basic liberalisation principles embodied in the EAs are preferential treatment, asymmetric reductions in tariffs and the respect of rules of origin.

These structural adjustment programs and the EU harmonisation process have dealt much less with the environmental distortions and, chronologically, environmental distortions have started to be analysed much after trade liberalisation issues. Tackling environmental distortions require a much more sophisticated and effective government and legal system that has only started to be built as part of the EU integration process and participation in MEAs and promises to continue on the medium and long term.

Intensive agriculture has negatively affected the fertility and quality of soil, has accelerated its erosion, and has disturbed the ecological equilibrium of the rural landscape. Pressures on the environment from agricultural production decreased during the transition due to lower consumption of inputs (mainly fertilisers and pesticides), contraction of large-scale operations created under the previous regime (livestock complexes) and due to a less intensive agricultural land use structure. At the same time, due to the reduction of government funds for support of irrigation, land amelioration and lack of producers' own funds to finance these activities, soil quality declined. The recent improvements in the environmental situation are the side effects of transition, and, other things constant, they are not sustainable over the longer term as economic pressures on producers decrease, providing more production incentives and enabling increased use of inputs.

Monitoring of air, water, and soil is still inadequate. Moreover, analytical methods are sometimes incompatible; there is a general lack of comprehensive quantitative information about pollution levels. Still, existing information is sufficient enough to identify *hot spots* that most deserve immediate response, although improved monitoring is necessary to formulate the most cost-effective solutions. While toxic emissions and discharges, which are a known risk to health should be dealt with on an immediate basis, a gradual approach should be adopted to enforcing environmental standards. In the coming years, the need to comply with more severe environmental standards and compliance with international conventions would demand the introduction of the state-of-art technologies in the CEECs for pollution abatement.

While policy measures dealing with point source pollution from agriculture are easier to be implemented, the non-point source pollution (NPS) (where monitoring individual emissions associated with farming activities and responsible for environmental degradation is not possible due to the number of sources, the diffuse character of pollution and stochastic elements) is still least controlled in the CEECs.

Policy-makers in these countries face difficulties in updating traditional pollution control strategies and regulatory approaches in order to address NPS problems. In the case of agricultural NPS pollution, due to the high cost of monitoring individual pollutant discharges, transaction costs (research, information gathering and analysis; enactment of enabling legislation including lobbying costs; design and implementation of the policy; support and administration of on-going programs; monitoring/ detection; and prosecution/ inducement costs) (McCann and Easter, 1999) associated with regulatory policies are particularly high.

Besides, in the CEECs, economic activities that are responsible for NPS pollution problems, agriculture in particular, have substantially been, and are still, although to a lesser extent, exonerated from mandatory regulation, and have not been confronted by effective economic incentives aimed at internalising the social costs of pollution. On the contrary, rather than addressing market failures and promoting a more sustainable use of natural resources, agricultural policies in transition countries have often added further distortions, and by so doing, have often worsened the misuse of resources.

Political acceptability of any environmental policy in agriculture is also influenced by the composition of the polluters. In the CEECs, for instance, environmental problems arising from agricultural production are caused by a large number of farms, the majority of which are family-owned operations with low financial means. Given the general need to continue to support these farms and the influence of the farm sector to get such support, any potential policy instrument will need to consider such political realities.

Still, small-scale farming in the CEECs pollute least compared to agricultural associations and state farms, as they usually use lower quantities of potentially polluting inputs. Nevertheless, NPS pollution does not depend only on the quantity of agricultural inputs used, but on farm location, inputs' application timing, technological practices, all corroborated with stochastic factors, which show that, after all, size of pollution source is necessary, but not sufficient in explaining environmental impacts.

The non-point nature of most agricultural externalities limits the applicability of conventional policies used to combat point-source externalities. NPS pollution problem requires the use of others than standard instruments of environmental policy (Pigouvian taxes, tradeable emission permits, emission standards) as incentives for dischargers to follow socially-desirable policies (see Griffin and Bromley, 1982).

Policy instruments aimed at controlling pollution from agricultural diffuse sources are divided into two categories, the *direct regulatory approach* (setting policy measures based on observable total discharges) and the *indirect regulatory approach* (based on estimated individual pollutant discharges). Few of them can be easily applied in the CEECs.

Policy instruments consistent with the direct regulatory approach typically take on the form of ambient *tax/subsidy policy schemes* that, broadly speaking, depend on deviations between measured and desired ambient pollutant concentrations. Each polluter pays a tax that varies proportionally with changes in the ambient concentration. Only information about the pollutant at the receptor site is required rather than emission levels of each polluter and, in addition to the reduced data needs, the mechanism is also budget balancing. This approach is less politically acceptable, however, given the separation between behaviour and penalty and this constraint applies mostly everywhere, not only in the CEECs case.

Policy instruments consistent with the indirect regulatory approach include: *estimated emission charges and standards (*there are no models applied in the CEECs that could provide accurate estimates of the complex fate and transport of most agricultural pollutants and accurate proxies are necessary if this indirect approach is to receive political legitimacy; even if the estimates were accurate, the costs of regularly applying these complex models, particularly in terms of data collection, would be so large as to outweigh any gains); *marketable emissions permit systems (t*he diffuse nature of agricultural pollution makes the use of conventional tradable permits infeasible, therefore they have been modified to a tradable permit system on polluting inputs and a point/non-point source trading scheme; neither of them can be applied in the CEECs due to data constraints); *input and output- oriented policy measures* (input and output levies, mandatory restrictions on input use, codes of good agricultural practice, agri-environmental programmes, cross-compliance measures, and compensation for abandonment of potentially polluting activities; some of these instruments are going to be applied in the CEECs after accession as they are common instruments applied in the EU).

No single economic instrument emerges as the ideal choice for reducing pollutants from agricultural production. Each are appropriate under certain circumstances but none by itself adequately addresses the informational and uncertainty problems associated with diffuse-source pollution prevalent in agriculture. For such problems, the costs of monitoring and enforcing a given policy are generally inversely related to its effectiveness in meeting the environmental target at minimum total abatement costs. Performance-based instruments such as emission and ambient charges are targeted directly at environmental quality but suffer from measurement problems, while design-based instruments such as input taxes can be implemented more easily but suffer from the indirect relationship between the chosen design base and environmental damage.

Current CEECs' policies have started to adopt an approach towards sustainability based on the integration of the environment into sectoral policies and the reshaping of social and economic behaviour through the use of a broader range of instruments and by promoting the principle of shared responsibility. The process of increasing environmental awareness has started and has been linked to the EU pre-accession process and CEECs' being part of world conventions on environmental issues. The CEECs' institutions and legislation in the agri-environmental field have been harmonised gradually according to the current EU framework and the process is to continue in the long term.

Thus, considering the gap between tackling the two different type of distortions, trade and environment, we have a classical second-best problem: in a world of multiple distortions, one cannot a priori determine whether eliminating some of them will be welfare-increasing. Moreover, the elimination of one type of distortions (the trade ones) has a theoretically ambiguous effect on the environmental stocks. In fact, this ambiguity is the reason why the removal of only the trade distortions may or may not be desirable. The environmental distortion implies income losses due to lower environmental stocks than what is optimal. If the trade reform reduces the wedge between actual and optimal environmental stocks then the trade reform is necessarily desirable, e.g., trade liberalisation is "win-win". If the environmental stocks fall, thus increasing the wedge between actual and optimal stocks, the trade reform may, but not necessarily, be perverse. In this case the welfare losses of the worsening of the environment would have to be weighted against the conventional efficiency gains of bringing domestic prices closer to world prices.

The issue may apply to CEECs case during their transition period in adopting the environmental legislative and institutional *acquis communautaire*, period different from one country to another and, would more likely affect the candidates to be integrated the last.

Whether, in practice, agricultural trade liberalisation will positively or negatively affect the quality of environment in the CEECs, cannot be ascertained before empirical analysis was undertaken. If we consider the opinion of the advocates of trade liberalisation, the trade effects on environment during transition will be not significant. Anderson (2002) makes clear that there is much more likelihood of agricultural trade liberalisation having a positive net effect on the environment than is often admitted by environmental groups, and that, where the environmental effect is negative, the extra damage caused by trade reform is only a insignificant fraction of that which would occur as a result of normal economic growth, the adverse welfare effects of which are likely to be far more than offset by the welfare gains from trade reform. Moreover, if the trade reform were to be accompanied by reform to environmental policies that brought them closer to optimal regulations, the likelihood of an even better outcome would be enhanced, as Beghin et al. (1997) demonstrate quantitatively in a case study of Mexico. The CEECs environmental policy is gradually reforming anyway, just more slowly than the trade reform pace.

Moreover, several specific factors are to be taken into consideration in the case of the CEECs (e.g., low agricultural inputs use, land ownership fragmentation, rationale of supporting subsistence farming, agricultural research funding, etc). Each of these might enhance the impact trade could have on environment and should be included in any modelling approach on trade-environment linkages.

2.2. Methodologies analysing the impact of agricultural trade on the environment in the CEECs in the context of the EU enlargement

Several researchers have already applied mixed methodologies to simulate the EU enlargement, although most of them not considering the environmental effects of the agricultural trade liberalisation.

To give a brief classification of agricultural trade models and of related resource and environmental modelling used for analysing the enlargement of the European Union, we use the reviews made by Anania (2001) and van Tongeren and van Meijl (1999). Another analysis of the differences between the types of models most frequently used today is found in Francois and Reinert (1997).

The Anania paper reviews the models used in the past decade to analyse the expected effects of liberalising agricultural trade with specific reference to the implications for agriculture and agricultural policies in the European Union and its trading partners, among which we will focus on the accession countries.

Within a project financed by the EU (FAIR6 CT 98-4148), van Tongeren and van Meijl carried out a study of the main simulation models of international agricultural markets and of the linkages between them and national policy interventions (van Tongeren and van Meijl, 1999; van Tongeren et al., 2001). Under the same project, a series of contributions recently made available analyse models using GTAP to study the expected effects of the CAP reform process (El Mekki et al., 2000), of the enlargement of the EU to include Eastern and Central European countries (Pohl Nielsen and Staehr, 2000) and of the multilateral process of liberalising policies and trade (Francois and Rombout, 2000).

The simulation models used in the 1990s to analyse the implications of a trade liberalisation for an enlarged EU agriculture differ in more than one respect; consequently, there are a number of axes along which one could define their taxonomy.

The most important distinction is that between partial equilibrium and general equilibrium models, the first ones being justified (Anania, 2001) only in cases when the particular product or group of products analysed represent such a small share of the overall economic system that a variation in its level of production or use can be assumed to cause no significant variations in other markets. As in industrial countries agriculture accounts for only a small share of GNP, the strength of the linkages of agriculture with other sectors is typically not very strong at the level of aggregation that general equilibrium models tend to employ. An exception may be those linkages than run through markets for natural resources, especially land. In contrast, CEECs witness a relatively high share of agriculture in economic activity. There are, therefore, significant second-round effects to be expected from policies that pave the ground towards the EU enlargement process, and general equilibrium models seem to provide the most coherent way to analyse these.

Both reviews discuss the strengths and weaknesses of the main partial equilibrium models used to analyse the EU agriculture: the EC ones (SPEL/EU-MFSS, SPEL TRADE), Bonn University (WATSIM), INRA (MISS), FAPRI (FAPRI-GOLD), OECD (AGLINK, MTM), FAO (WFM), USDA (SWOPSIM), and several others. Among the general equilibrium models, they mention ECAM, CAPMAT, RUNS, GTEM, GTAP, WTO housemodel, G-cubed that were used and adjusted by several economists to consider specific issues (mainly GTAP, which is the most popular).

Among the main weaknesses of some of the above models, Anania (2001) mentions the flaws lying with some hypotheses (EU treated as a "small" country; the way competition and market structure are treated in some models; product homogeneity issue - Armington approach followed most often by general equilibrium models-; indirect representation of trade policies through the use of "equivalent tariffs"; the issue of representing trade policies through explicit modelling - which is, in authors' opinion, the only effective way to conduct simulations of EU agricultural policies, by modelling the CAP instruments explicitly, one at a time) and the ways of dealing with the 1994 GATT Agreement commitments (reduction in domestic support; increasing market access; reduction of subsidised exports).

We consider here the models dealing with the EU enlargement. Assessments of the likely impacts of extending CAP to the CEECs have been a popular subject of research and investigations. The methodology applied varies from using the back of an envelope to computable general equilibrium models. All studies indicate that it would be quite costly for the EU's budget to extend the present CAP to the CEECs.

Which are the best models for simulating the effects of a regional, rather than global, trade liberalisation, as the enlargement of the EU to Central and Eastern European countries? Anania (2001) analyses the weaknesses of some of the models constructed with the specific objective of evaluating EU enlargement. Not being "spatial", most models are structurally incapable of simulating the effects of "discriminatory" trade policies, such as preferential trade policies, the creation of a customs union or the enlargement of an existing one. That said, "non-spatial" models are used to predict the effects of discriminatory trade policies – including the enlargement of the EU to CEECs - by assuming imperfect substitution according to the country of origin of the product. In all cases where discriminatory trade policies cannot be ignored - either because they are themselves the focus of the simulation, or because they are relevant for the markets considered - the model ought, according to Anania (2001), to be a genuinely "spatial" model, i.e. its structure ought to be able to reproduce trade flows between each pair of countries without having to resort to additional hypotheses.

Clearly, spatial modelling provides a richer and more detailed picture of the market, but requires much more data, parameters, bookkeeping and computational effort. Whether the additional effort is justified by additional relevant information is dependent on the kind of problems a model has to tackle. Many policy disputes and policy instruments are bilateral in nature, and international economic relations should be modelled at the same level.

An example is ESIM, where a single region, "rest of the world", is added to seven Eastern and Central European candidate countries and the current EU member states; this "rest of the world" is treated as completely exogenous and is assumed to be unaffected by the enlargement and the associated policy changes.

Using a non-spatial multi-product partial equilibrium model (CEASIM, Central European Agricultural Simulation Model), Frohberg et al. (1998) analyse the entry of Eastern and Central European countries into the EU. CEASIM models eight candidate member countries separately, but considers all the others - EU countries included - as a single unit, and assumes that the equilibrium price in this aggregate is exogenous for the Eastern and Central European countries considered. The analysis is conducted considering the likely effects of different price levels and the introduction of production quotas for milk and sugar in the new member states. The structure of the model, however, does not allow either for changes in trade policies in these countries as a result of enlargement (it is not possible to consider the elimination of trade barriers with the other members, nor the aligning of tariffs and export subsidies), or for border price adjustments following enlargement. Moreover, these are the same regardless of the fact that the exports (imports) of the new members are directed towards (coming from) the EU or towards (from) non-member states. All this renders the hypotheses problematic and considerably reduces the credibility of the results.

Gehlhar (1998) simulated the effects of EU enlargement to CEECs making the tariffs on imports from third countries uniform and eliminating the tariffs on trade between the new Central and Eastern European members and the countries of the EU-15, but left unchanged both domestic support for farmers and export subsidies in the new member countries.

Liapis and Tsigas (1998) unify border protection policies of the new members and EU-15, eliminating trade barriers between them, making support to domestic farmers uniform, but leaving export subsidies unchanged.

GTAP makes the assumption of imperfect substitutability in consumption according to their country of origin, therefore simulations of regional trade liberalisation processes appear linked to implicit assumptions on the homogeneity, or lack of it, of products, which is not always easily justifiable. When GTAP is used to simulate the enlargement of the EU (considered as a single country) to Central and Eastern European countries, in the best of cases this happens eliminating barriers to trade and exports subsidies between these and the EU, and bringing domestic and trade policies of the new members into line with the policies of the EU (in the latter case totally or only partly, depending on the assumptions made regarding the reform process of the CAP before the enlargement). The simulation will assume that after the enlargement goods produced by the original EU member countries will remain imperfect substitutes of those produced in the new members. However, since these goods are going to be produced within the same market and subject to the same rules and regulations, this hypothesis is hard to justify. Moreover, it can lead to serious distortions in the simulation results. Anania (2001) considers as more reasonable to assume perfect substitutability after the enlargement between goods produced by old and new member countries, or, at least, to introduce a discernible change of the parameters of the model in this direction.

Paarlberg et all (2001) examines five critical aspects of EU enlargement and whether they can be addressed in general equilibrium Ricardo-Viner models of transition economies. Some aspects of EU enlargement fit well into the modelling framework. By design the models are intended to examine the impact of commodity policy changes like introduction of the Common Agricultural Policy. Nevertheless, decisions on how to treat EU direct payments or the magnitude of price changes are not clear, but control the magnitude and pattern of results. Labour market adjustments can also be modelled using this framework, but the assumed closure rule largely determines the direction of impacts. Other issues do not fit well into the modelling framework. For example, while the model can indicate how the land rent changes due to output price changes, it is more difficult to analyse the impact of allowing foreign land ownership. Structural fund expenditures that alter product quality cannot be analysed satisfactorily because goods are treated as homogeneous.

Another attempt to model EU enlargement was made by a group of Danish researchers, using the GTAP modelling framework (Frandsen, Bach and Stephensen, 1996). The authors constructed a baseline scenario of the CAP 2010 as a base for comparison, rather than using the present situation. Looking at the impact on economic welfare, the results indicate that extension of CAP leads to income losses in both the CEECs and the EU as a result of higher taxes in the EU to finance extra costs, as well as due to the loss of efficiency caused by the less than optimal allocation of the factors of production and the patterns of consumption in both regions. In the CEECs, in particular, agriculture expands on the account of industry. The CEECs obtain, however, a significant term of trade gain as well as an income transfer. The overall result is a net loss for the EU and a net gain for the CEECs, the gain exceeding the loss.

Several authors analysed the effects of agricultural trade liberalisation using mixed methodologies. Van Tongeren, van Meijl and Veenendaal (2000) used two different kinds of general equilibrium models jointly; Münch and Banse (1999) used partial equilibrium model combined with single country general equilibrium models; CAPRI Project (Heckeley and Britz, 1999) produced a model in which roughly 200 mathematical programming regional models, which simulate aggregate decisions at the level of individual farms, were employed using prices generated by a spatial equilibrium model (derived from WATSIM), which, based on the results from the first models, calculated the equilibrium price in each country; a similar approach was adopted by the EUROTOOLS Project (2000) where University of Reading's Land Use Allocation Model (LUAM) was extended to the European Union and expanded in order to determine consumption, prices and the net trade position of each country endogenously; Serrão (1998) vertically integrated an econometric model (evaluating the effects of the CAP reform on different sectors) and an input-output model, using the results obtained relating to land allocations and input uses to calculate indicators of the environmental impact of the CAP reform.

One of the few papers considering the environmental effects of agricultural trade liberalisation in the context of EU enlargement is authored by Zhu and Ierland (2001). They investigate the consequences of the enlargement of the EU on trade and environment by general equilibrium modelling. A general equilibrium model with the sequential joint maximisation method is developed to examine the impacts under different environmental regimes. The model is capable of analysing the effects of accession to the EU on the markets (prices of the goods) and the environment in both acceding regions and the EU. For illustrative purposes, the model is applied in a numerical example with two regions (EU and CEECs) and two goods (pollution intensive good A and clean good B). The model is also run for some environmental policies. Considering the common environmental policies within the EU, e.g. the commitment of the emission abatement of EU in Kyoto protocol, the model is also run for some scenarios of different environmental policies to check the effectiveness of these policies. The results of various scenarios show that the 'unilateral environmental policy in EU' under free trade is not efficient for uniformly mixing pollutants, because emission leakage may occur in the CEECs. The 'uncoordinated environmental policy in EU and CEECs' is not efficient either, because specialisation in production is hampered when environmental constraints are imposed upon both regions. The 'coordinated policy in EU and CEECs' could be efficient to restrict the total emission level for uniformly mixing pollutants, because it brings maximum economic welfare for both regions under the given emission ceiling. The paper highlights the importance of the coordination of environmental policies in the EU and CEECs.

Although some of the above models could be adjusted to take into consideration the environmental dimension, most of the EU enlargement models do not tackle the issue, mainly due to data availability.

As partial and general equilibrium models are already popular in dealing with the EU enlargement, it might appear to be technically and financially easier to invest in environmental data collection needed to adjust these models as to include the agri-environmental component than to apply other methodologies available mostly at a theoretical level. Besides, equilibrium models are more feasible than mathematical programming models from the data requirements point of view.

Nevertheless, the selection of most appropriate methodologies should be based on their being able to answer the questions they are posed. Namely, just adjusting existing models might not be accurate to deal with the CEECs special case, in which case, new models should be created and applied, as the higher costs related to data collection and methodology creation and implementation would be lower than those implied by inaccurate adjustment of existing modelling approaches.

We base this on the findings of Anania (2001) who states that, besides the models which are reliable both on account of their structure and for the quality of the data they use, there are others, for one reason or another, with a large question mark over their ability to supply adequate answers on the effects of the changes in domestic and trade agricultural policies. “The most important thing is that greater care and attention must be paid in tailoring models to answer the specific questions addressed, and abandoning once for all the claim that, once it has been set up, a model can be used to simulate any change in the policy scenario whatsoever” (Anania, 2001).

The models should describe the most important policy instruments used explicitly, one by one, in order to allow researchers to simulate variations in the use of each of the instruments. As Anania (2001) states, EU enlargement simulation models should be carried out with a genuinely “spatial” general equilibrium model, which is capable of simulating both the direct market effects in the new member countries, and the indirect macroeconomic feed back from these effects on agricultural markets in all countries in terms of variations in the demand for agricultural products and the allocation of resources.

Having in view the diversity of environmental problems occurring in the CEECs, once the data availability problem would be solved (long-term issue due to financial constraints), a mix of methodologies will be most indicated to measure the environmental impact of agricultural trade liberalisation. Instead of trying to adapt a model to measure effects that it is not designed for, it would be far more useful to use different models jointly, each one reproducing part of the mechanism which will yield the final result, by exploiting its specific strengths.

The availability of environmental data needed to analyse the effects of various policy instruments constitute the main reasons for the lack of applied methodologies to measure trade-environment linkages in the CEECs. As data on trade between the CEECs, EU and third countries rises few availability issues, reliable environmental data is still highly missing for most of the CEECs. There are potentially a large number of indicators that could be developed to help quantify the various components and linkages in the agri-environmental framework. In the case of most CEECs, a more or less complete database exists and allows to calculate some indicators, nevertheless problems of data definitions, quality, the regularity of data collection and methods of indicator measurement remain obstacles to progressing the work on most of agri-environmental indicators.

Much of the basic data required to derive *nutrient balances*, such as on farm fertiliser use, livestock manure, numbers and composition of live-stock, and crop production, are widely available and regularly updated for the CEECs. The availability of coefficients to determine the quantity of livestock manure produced by livestock and its nutrient content, and the uptake of nitrogen by crops and pasture, however, is more limited at a regional level, although standardised coefficients have been developed.

Data on *pesticide use* is available, although the time series is not fully complete. A problem is identifying pesticide use for specific crops. CEECs have data series on the area of land to which pesticides are applied but spatially referenced data are limited. The development of a pesticide risk classification system is not complete and it has not allocated quantities of pesticides used into different risk categories.

The major issue to be considered in response to developing *agricultural water use* indicators is the extent to which the use of water resources can be linked to agriculture. Data are available on overall water withdrawal rates and major users in the CEECs economies are identified. The major agricultural use of water supply is for irrigation. Nevertheless, data on irrigation abstraction rates, combined with information collected in relation to farm management indicators, particularly irrigation management indicators do not exist. This data would help to reflect linkages between agricultural water usage and problems of water depletion.

Data on changes in national *land use* patterns, both between agriculture and other land uses and within agriculture, are also available for most of the CEECs. However, definitions of land use types, such as "permanent grassland" vary widely when compared to other countries. The data required to measure indicators that address the issue of land conservation are only beginning to be collected. However, given the close links between agricultural land use, land conservation and other issues – for example, water use, soil and water quality, farm management, wildlife habitats, agricultural landscape, and socio-cultural issues – there may be considerable scope to utilise this wider range of indicators and related basic data.

The CEECs have data on different types of *soil degradation* at national level. The methodology to measure the "risk" of potential soil quality deterioration is still in the development stage, although, at least for soil erosion, the Universal Soil Loss Equation has been used to estimate soil erosion rates, which can then be reported in „risk" classes.

As regards *water quality*, the major difficulty is to identifying agricultural sources of pollution, as these are often diffuse and may have effects with a long time lag. Determining the contribution of diffuse pollution sources, such as nutrient run-off from fields, to a given environmental impact is much more difficult than for point sources. Also, water is not always an appropriate sampling medium for many farm contaminants which are stored in sediment or may bio-accumulate. Most of the CEECs have no data on different types of water pollutants specific to agriculture, although more general data are available.

The „risk" approach uses data related to nutrient balances, pesticide use and soil characteristics, for example, and thus incorporates much information addressed by other agri-environmental indicators. Most of the CEECs have not yet developed risk-based methods to measure water quality, especially as these can be directly linked to agriculture. Such approaches may provide early warning of potential problems and are not costly to monitor for national administrations.

All methods for calculating *greenhouse gases* are subject to uncertainty, due to the error margins that are involved with the assessment of emissions and sinks related to agriculture. In the CEECs, as in most countries, while the sources and sinks of agriculture are reasonably well known, their magnitude is more uncertain depending on factors relating to soil, climate and management.

The CEECs have just started to address the issue of *biodiversity* in relation to agriculture, at both the conceptual and empirical level. This work is exploring a number of indicators to measure biodiversity, including for example the extent of diversity of varieties of crops and livestock breeds in agricultural production, and whether production is taking place on a narrow genetic base. Most CEECs have monitored changes in „key indicator" wildlife species (plants, insects and animals) in general, and not specifically in their relation to agriculture (e.g., by monitoring the changes of wildlife species that reside in or are in close proximity to agro-ecosystems). Work is underway to establish information on wildlife habitats by use of satellite based remote sensing in conjunction with analysing this information by the use of geographic information systems.

Besides coping with reliable databases availability issue, CEECs should invest in training researchers to use these methodologies and the software packages attached. The two issues are inseparable in reaching accurate methodological outcomes: well-designed models need good quality data. Data requirements are very demanding (in volume and consistency) for multi-regional models of international trade. The amount of data is determined by the level of disaggregation (countries/ regions, activities/ commodities) and the theoretical structure (homogeneous/ heterogeneous goods, bilateral/ pooled markets).

The parameters used in behavioural equations determine the response to policy changes, and are therefore a basic element in each modelling exercise. Key parameters are: price and income elasticities and budget shares in demand systems; substitution elasticities and input cost shares in supply systems; Armington (substitution) elasticities in import demand; if economies of scale are included, parameters that capture the degree of exhaustion of returns to scale (cost-disadvantage ratio). The values of these parameters must be determined in consistency with data and theory. A promising approach to overcome the environmental data availability has been introduced by Dessus, Roland-Holst and van der Mensbrugghe (1994). Environmental appraisals of trade reforms can be undertaken on the basis of simulated changes in the use of polluting intermediate inputs for which data is more readily available than emissions data.

CONCLUSION

Current CEECs' policies have started to adopt an approach towards sustainability based on the integration of the environment into sectoral policies and the reshaping of social and economic behaviour through the use of a broader range of instruments and by promoting the principle of shared responsibility. The process of increasing environmental awareness has started and has been linked to the EU pre-accession process and CEECs' being part of world conventions on environmental issues. The CEECs' institutions and legislation in the agri-environmental field have been harmonised gradually according to the current EU framework and the process is to continue in the long term.

As associated countries, CEECs have paid increased attention to trade agreements with the EU. Still, the linkages between trade and environment have only started to be considered by researchers and policy makers.

There are few empirical attempts to measure the impact of agricultural trade liberalisation on environment in the CEECs. Although the some of the existing models used to simulate the EU enlargement could be adjusted to take into consideration the environmental dimension, few of them tackle the issue. This is mainly related to data availability problem.

Having in view the diversity of environmental problems occurring in the CEECs, once the data availability problem would be solved (long-term issue due to financial constraints), a mix of methodologies will be most indicated to measure the environmental impact of agricultural trade liberalisation. The selection of most appropriate methodologies should be based on their being able to answer the questions they are posed.

Besides coping with reliable databases availability issue, CEECs should invest in training researchers to use these methodologies and the software packages attached. The two issues are inseparable in reaching accurate methodological outcomes: well-designed models need good quality data.

Applying methodologies to measure the impact of agricultural trade on environment would provide policy makers in the CEECs with better feedback on the impact of their trade decisions on agri-environmental issues, a field that has recently started to be of critical interest in the CEECs, mainly as a result of the EU harmonisation process. The policy makers in environmental field are confronted by the need of setting up a coherent framework for the decision making process.

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BUILDING AGRO-ENVIRONMENTAL INDICATORS BY INTEGRATING BIO-PHYSICAL AND ECONOMIC MODELS FOR ASSESSING THE SUSTAINABILITY OF AGRICULTURAL TRADE LIBERALISATION

Guillermo Flichman

SUMMARY

This article reviews the basic theoretical and practical issues concerning agro-environmental indicators, taking into account the specific characteristics of relations between agricultural production and environmental externalities.

The first section contains an overview of environmental indicators and agriculture. In most cases these indicators are technical coefficients of emissions related to levels of production or consumption. In order to analyse agriculture environmental impacts, there are specific problems that have to be taken into account if we want to provide a sound assessment of sustainability. Agricultural activities have very complex relations with the environment and natural resources (or natural capital). In this section, some specific considerations are developed regarding the differences and conflicts arising between spatial negative externalities (principally diffuse pollution) and temporal externalities, related to the deterioration of natural capital, which creates negative transfers to future generations (raising a sustainability issue).

In the second section, we develop some theoretical elements and empirical evidence of specific difficulties related to agricultural externalities, which frequently have discontinuous and non-convex relations with levels of production and/or inputs used. These characteristics make it particularly difficult to apply some of the usual environmental policies used when externalities (i.e. industrial pollution) relate to production levels through linear or at a minimum, continuous and monotone functions. This creates complications regarding the type of indicators that can be really useful.

The third section presents the type of information ideally required to produce indicators of agro-environmental impacts arising from policy changes. We present the type of information needed and the tools available for producing such indicators; in other words, the *state of the art*. For this purpose, we make a synthetic description of the existing bio-physical models that can be used to provide this information, as well as of the particular problems of integrating that information in economic models.

The fourth section deals with a specific proposal of what could be done in Europe in order to develop this field of applied research.

ABSTRACT

This article reviews the basic theoretical and practical issues concerning agro-environmental indicators, taking into account the specific characteristics of relations between agricultural production and environmental externalities.

The first section contains an overview of environmental indicators and agriculture. Agricultural activities have very complex relations with the environment and the natural resources (or natural capital).

The second section deals with some theoretical elements and empirical evidence of specific difficulties related to the analysis and measurement of agricultural externalities. These externalities frequently have discontinuous and non-convex relations with levels of production.

The third section presents the type of information ideally required to produce indicators of agro-environmental impacts arising from policy changes, in other words, the *state of the art*.

The fourth section deals with a specific proposal of what could be done in Europe in order to develop this field of applied research.

JEL Classification: B41, D62, N50

Key Words : agriculture; externalities; environmental indicators; bio-physical models; trade liberalisation.

CONSTRUCTION D'INDICATEURS AGRO-ENVIRONNEMENTAUX PAR COUPLAGE DE MODÈLES BIO-PHYSIQUES ET ÉCONOMIQUES POUR ÉVALUER LA SOUTENABILITÉ DE LA LIBÉRALISATION DU COMMERCE AGRICOLE

RÉSUMÉ

Cet article examine les questions théoriques et pratiques fondamentales relatives aux indicateurs agro-environnementaux, en prenant en compte les caractéristiques spécifiques des relations entre production agricole et externalités environnementales.

Dans la première partie, nous passons en revue les indicateurs environnementaux concernant l'agriculture. Dans la plupart des cas, ces indicateurs sont des coefficients techniques d'émissions liés aux niveaux de production ou de consommation. Pour analyser l'impact de l'agriculture sur l'environnement, nous devons prendre en compte des problèmes spécifiques si nous voulons fournir une évaluation valable en termes de durabilité. Les activités agricoles ont des relations très complexes avec l'environnement et les ressources naturelles (ou capital naturel). Dans cette partie sont exposées quelques considérations concernant les différences et les conflits survenant entre les externalités spatiales négatives (principalement la pollution diffuse) et les externalités temporelles liées à la détérioration du capital naturel, qui créent des transferts négatifs vers les générations futures (soulevant ainsi un problème relevant de la durabilité).

Dans la deuxième partie, nous exposons quelques éléments théoriques et résultats empiriques montrant les difficultés spécifiques liées aux externalités agricoles, qui ont fréquemment des relations discontinues et non convexes avec les niveaux de production et/ou les inputs utilisés. Ces caractéristiques rendent particulièrement difficile l'application des politiques environnementales habituelles, utilisées quand les externalités (c'est-à-dire la pollution d'origine industrielle) sont liées aux niveaux de production par des fonctions linéaires ou tout au moins continues et monotones. Cela crée des complications en ce qui concerne le type d'indicateurs qui peut vraiment être utile.

La troisième partie présente le type d'informations requises dans l'idéal pour produire des indicateurs agro-environnementaux des impacts de changements de politiques. Nous présentons le type d'informations nécessaires et les instruments disponibles pour produire de tels indicateurs : en d'autres termes, *l'état de l'art*. Pour cela, nous faisons une description synthétique des modèles biophysiques existants qui peuvent être utilisés pour se procurer ces informations, ainsi que des problèmes particuliers d'intégration de cette information dans les modèles économiques.

La quatrième section traite d'une proposition spécifique de ce qui pourrait être fait en Europe pour développer ce champ de recherche appliquée.

RÉSUMÉ COURT

Cet article examine les questions théoriques et pratiques fondamentales relatives aux indicateurs agro-environnementaux, en prenant en compte les caractéristiques spécifiques des relations entre production agricole et externalités environnementales.

Dans la première partie, nous passons en revue les indicateurs environnementaux concernant l'agriculture. Les activités agricoles ont des relations très complexes avec l'environnement et les ressources naturelles (ou capital naturel).

La deuxième partie traite de quelques éléments théoriques et résultats empiriques montrant les difficultés spécifiques de l'analyse et de la mesure des externalités agricoles, Ces externalités ont fréquemment des relations discontinues et non convexes avec les niveaux de production.

La troisième partie présente le type d'informations requises dans l'idéal pour produire des indicateurs agro-environnementaux des impacts de changements de politiques, en d'autres termes, l'état de l'art.

La quatrième section traite d'une proposition spécifique de ce qui pourrait être fait en Europe pour développer ce champ de recherche appliquée.

Classification JEL : B41, D62, N50

Mots-clefs : agriculture ; externalités ; indicateurs environnementaux ; modèles bio-physiques ; libéralisation commerciale.

BUILDING AGRO-ENVIRONMENTAL INDICATORS BY INTEGRATING BIO-PHYSICAL AND ECONOMIC MODELS FOR ASSESSING THE SUSTAINABILITY OF AGRICULTURAL TRADE LIBERALISATION[31]

Guillermo Flichman[32]

INTRODUCTION

It is becoming increasingly relevant to introduce the environmental dimension in economic modelling. Forecasting the impact of changes in trade policies requires an assessment of the environmental effects of those changes. In this field, very important progress took place in the last decades, especially through the use of what is usually called "environmental indicators". Different types of models, in particular Computable General Equilibrium (CGE) models dealing with international trade make use of these types of indicators. In this paper, we deal with the specific problem of creating indicators relating to environmental and natural resources affected by agricultural activities in the context of trade liberalisation.

In the first section, we develop a general view on environmental indicators and agriculture. In most cases these indicators are technical coefficients of emissions relating to levels of production or consumption. In order to analyse agriculture environmental impacts, there are specific problems that have to be taken into account if we want to provide a sound assessment on sustainability. Agriculture activities have very complex relations with the environment and the natural resources (or natural capital). In this section, some specific considerations will be developed about the differences and conflicts between spatial negative externalities (principally diffuse pollution) and temporal externalities, relating to the deterioration of natural capital, which creates negative transfers to future generations (sustainability issue).

We develop in the second section some theoretical elements and empirical evidence of specific difficulties relating to agricultural externalities, which frequently have discontinuous and non-convex relations with levels of production and/or inputs used. These characteristics make it particularly difficult to apply some of the usual environmental policies used when externalities (i.e. industrial pollution) relate to production levels through linear or at a minimum, continuous and monotone functions. This creates complications regarding the type of indicators that can be really useful.

In the third section, we present the type of information ideally required to produce indicators of agro-environmental impacts arising from policy changes. We present the type

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of information needed and the tools available for producing such indicators; in other words, the *state of the art*. For this, we will make a synthetic description of the existing bio-physical models that can be used to provide this information, as well as the particular problems of integrating that information in economic models.

The fourth section will deal with a specific proposal of what could be done in Europe in order to develop this field of applied research.

1. AGRICULTURAL ENVIRONMENTAL INDICATORS

The general relationship existing between trade liberalisation, environment and agriculture have been frequently discussed. From a purely conceptual, theoretical point of view there is only one conclusion that seems valid; namely that there is no possible generalisation about the environmental impacts of trade liberalisation. Even if the general impact is theoretically to increase income, it is not clear what the impact on the environment will be from this increase. The existence of market failures in environmental goods refutes the hypothesis of the generally positive impact of liberalisation on the environment and natural resources. All the literature on Trade and Environment shows contradictory examples, according to specific situations. That is why it is important to incorporate environmental indicators in trade liberalisation models.

In most cases these indicators are technical coefficients of pollution emissions relating to levels of production or consumption. These indicators are usually presented as a matrix based on the amount of specific pollutant emission per unit of production. There are different sources from which economists modelling the impacts of changes in trade regulations can obtain these coefficients. They have been produced by national and international organisations for several countries. The World Bank and OECD provide an important source for this type of information.

In some cases, modellers implement a further disaggregation of activities by types of technique, including two different sets of coefficients, one for the "conventional" technique and another one for the "environmentally friendly" technique. If information about the different costs of these alternative techniques, it is possible to analyse the trade-offs between the reduction in pollution levels and the increase in costs associated with such a reduction.

The improvements made in the last decade, relate essentially to (i) the relations between environmental quality of goods and demand, and (ii) the differentiation of techniques from the supply side. The first point relates to what is called the "Kuznets function", which argues the existence of a non-monotony relationship between the level of damage to the environment and the level of revenue: in a first stage of growth, damages increase, but after some threshold (difficult to determine) they diminish (Runge, 1998). But even if an important improvement in the way of dealing with the relations between trade and environment has taken place, there are some common features in the way agro-environmental indicators are produced and used, which show important limitations. These limitations relate to the type of information which is used and the implicit assumptions regarding technology.

An indirect representation of technology (dual approach) through production costs, as is the case in almost all models dealing with trade, is not adequate to represent the complex relationship between agriculture, environment and natural resources. A primal approach to technology, using what is called "engineering production functions" (Chenery, 1949) appears to deal more adequately with that complexity. We need to explicitly use the technical information regarding physical quantities of inputs and outputs, taking into account the production of externalities as part of the output.

It is necessary to recall the fact that there are two problems with the sustainability issue: One relates strictly to the field of conventional environmental economics, in other words, the existence of negative externalities relating to economic activities. Most environmental indicators deal with this dimension of the problem, as long as they relate activity levels with pollution emissions. The other one deals with long term impacts of economic activities on natural resources, such as soil degradation (erosion, salinity, acidity) and depletion of water resources. Building indicators for this second type of problem is even more complex, because it is necessary to take into account impacts occurring over a long period of time. We will differentiate between these two problems.

1.1. Agro-environmental indicators relating to negative spatial externalities

This is typically the case of emissions relating to agricultural production: e.g. different type of gases with "greenhouse effect", nitrate lixiviation in the water (rivers and aquifers), chemical pollution relating to pesticide and herbicide applications.

The usual way of dealing with this issue is to use emission coefficients per unit of production. For example, one unit of wheat in a specific region of the world is associated with a certain amount of nitrates emission, etc. Two types of problems appear with this approach. If there is a change in the market situation created by a trade liberalisation policy, such as a pricing increase, production will also increase. But one characteristic of agriculture production is that there is always one fixed production factor: land of a certain quality. In most cases, an increase in production implies a change in the techniques used, which means a change in the technical coefficients, including those relating to nitrate pollution. If, in the situation before the increase in international prices, the technique applied corresponds to a certain amount of fertiliser, associated with a quantity of nitrate emission, the increase on production - in the simpler case - will imply an increase in the level of pollution more than proportional to the increase in fertilizer. This change of technique does not imply that we are moving to a different production function. As long as we consider the notion of production function as the available input-output relationships at a certain level of knowledge, we remain in the same production function. We consider that there is a shift of the production function only if technical progress is taken into account and this is not the case. We are just changing the proportion of factors within available technical possibilities. The technical coefficient of nitrate pollution, even in this extremely simple case, is not linear with production. And the parameters of the functions relating to the increase in production with the increase in pollution are specific to one agricultural region. This means that when we apply a uniform coefficient of nitrate pollution for one ton of wheat, we are definitely making an enormous error.

The second problem is that in agriculture there is usually a situation of multiple productions. On the same plot of land, different crops are produced following a certain rotation. Changes in the combination of crops imply changes in the quality and quantity of inputs used in a specific crop that takes part in the rotation (agricultural rotations frequently create scope economies).

One example is the situation that occurs in some European regions with the reform of the Common Agricultural Policy. If the system of subsidies changes and all crops receive the same level of support, distortions will be reduced and economic efficiency will increase. At a regional level, this means that the level of specialisation of agriculture will increase. Taking the specific example of South-West of France, the area used for oilseeds will be less and the area used for cereals will increase. The use of pesticides and herbicides is completely different because of the rotation system. This means that specialisation in cereals will increase economic efficiency but will also increase negative environmental externalities as a consequence of permanent cereal production. Monoculture needs a higher amount of pesticides and herbicides than a rotational scheme.

We also encounter very complex situations with animal production. Emission coefficients per unit of production are not realistic. Pollutant emissions are different according to the type of techniques used. The feed component is essential to define these emissions. That is the reason why it is impossible to obtain good indicators if the technology is based only on cost, without an explicit specification of the physical inputs used in production.

These considerations correspond to the most simple situation of negative spatial externalities. In the second section of this paper we will deal with more complicated situations, when the functions relating to production and negative externalities are non monotone or even non convex.

1.2. Agro-environmental indicators relating to negative temporal externalities

In this sub-section we deal with problems relating to the effect of agricultural production activities over time. Typical cases of these externalities are land degradation and resource depletion.

What type of indicator can be used for these cases? A physical indicator, measuring the level of deterioration of the resource seems to be an adequate choice. If this is the case, it should be possible to indicate directly the tons of land eroded, the cubic meters of water exhausted or the increase in the level of salinity of the soil. As in the previous case, these indicators will not give a direct economic measure of the sustainability impact. For obtaining such a measure, we must make assumptions regarding technological change and use a dynamic inter-temporal model incorporating the change in the resources relating to agricultural production and the impact of that change on future production.

The information required for building these indicators is even more difficult to obtain than the one needed for the indicators relating to spatial negative externalities. In the former case, information is available, even if its rapid use may lead to erroneous results. In this case, information is not only site specific, but it needs a specification relating to a certain time horizon. We can see an example of this problem in the case of the impact of the amelioration of international cereal prices in Argentinean agriculture (Runge, 1998). The maize production in the pampas region was developed on rain fed conditions since the end of the nineteenth century. A dramatic increase of production took place in recent years, associated with the improvement of international prices that allowed the introduction of irrigation. Water comes from an aquifer that is not very well studied, but it has already been confirmed that three sustainability problems are arising: the quality of the water of the aquifer is deteriorating due to salinity and nitrates lixiviation. On the other side, erosion problems diminish, because of higher usage of herbicides reduced tillage, whereas chemical pollution increases. Two negative consequences appear as well as a positive one. What simple indicator can be used to deal with this complex situation? It is clear that there is no single answer, but a wide field of research needs interdisciplinary efforts. If we consider the incorporation of irrigation was a consequence of changes in trade conditions, we can obtain not one, but several environmental and resource indicators that may be in contradiction with each other.

Working with these problems requires specific tools. It seems extremely difficult to incorporate everything in a trade model. But it is possible to produce with a trade model the indicators that can provide information to be included in specific regional dynamic models designed to deal with long-term economic effects of changes in resource usage. We will develop a specific methodology that could be used for doing this in the last section of this paper.

2. AGRICULTURAL EXTERNALITIES AND ENVIRONMENTAL POLICIES

The definition of environmental policies is based upon the assumptions that are developed in the theoretical approach of environmental economics. One basic assumption relates to the type of function that characterises the production of negative externalities. In almost all the literature on environmental economics, external costs are supposed to be continuous and monotonous functions.

In order to show the differences between the conventional approach and what can be found in reality in many agricultural externalities, we will develop briefly the classical example of a firm (A) localised near a river, where it rejects pollutants that create a cost to another firm (B) down the river (Bonnieux and Desaigues, 1998)

Firm A produces Y at P price using a unique production factor X (used as numeraire). Profit, for firm A is

$$\Pi = PY - X$$

and the private cost function is defined as

$X = Y^2$ (1)

In order to maximise private utility, we should obtain

$PY - Y^2 \quad MAX$ (2)

The optimal private level of production is then

$d\Pi/dY = \Pi_m = P - 2Y = 0$ (3)

$\Pi_m =$ marginal profit

Optimal private level of production is in this case,

$Y^0 = P/2$ (4)

Taking into account we have pollutant emissions relating to the production level, we define the pollution function as

$L = aY^2 \qquad a > 0$ (5)

With a defined as a technical parameter.

These emissions affect firm B with a unit cost C, total external cost is then

$EC = CL$ (6)

This external cost is a positive function that increases with the pollution level and with the level of production of firm A. This means that the marginal external cost increases for each unit of increase in production and tends towards zero when production tends towards zero.

In order to calculate the social optimum Π S, we have to introduce the external cost in the calculation.

$\Pi S = PY - X - EC$ (7)

Social maximum utility will be

$PY - Y^2 - Ca\, Y^2 \quad MAX$ (8)

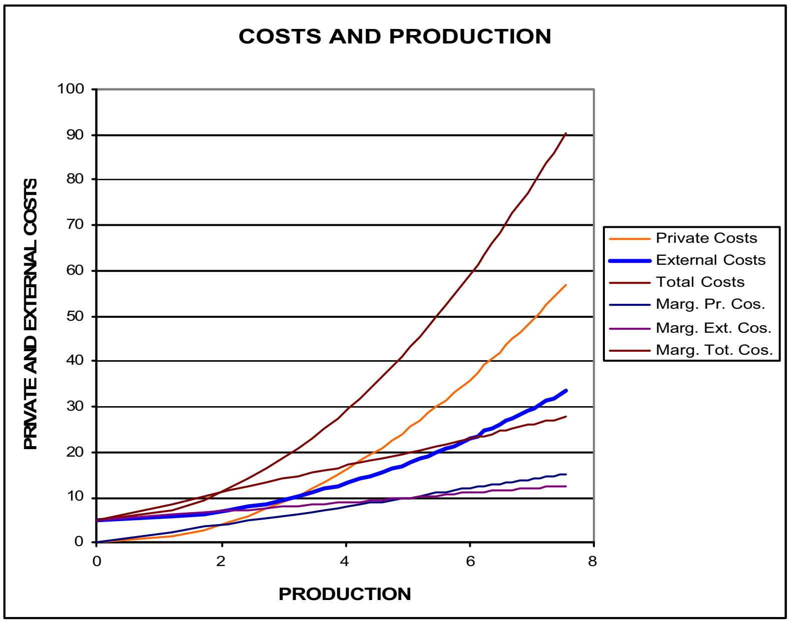
$d\Pi S/dY = \Pi S_m = P-2(1+aC)Y = 0$ (9)

$Y^* = P/2(1+aC) < Y^0$ (10)

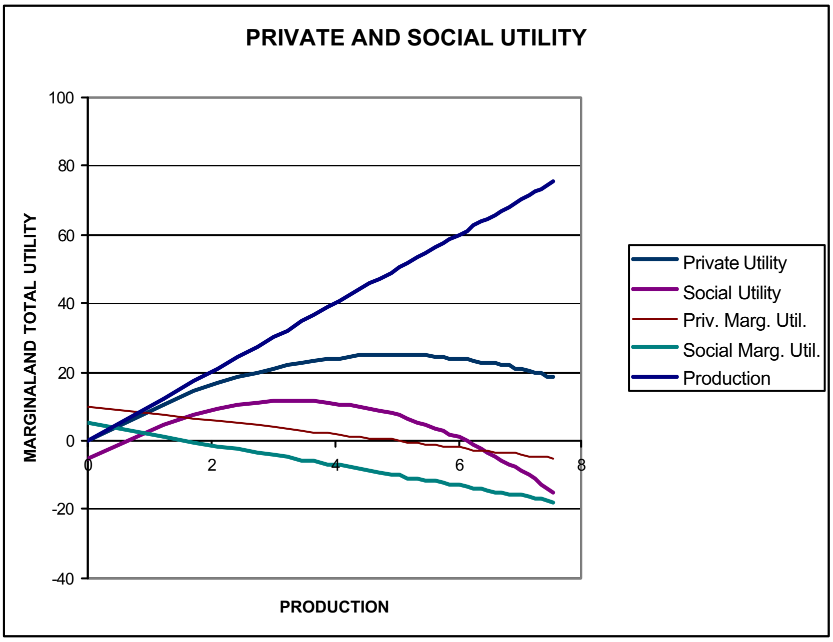
This example shows the type of externality function that is currently accepted: when we include the social cost to obtain the social utility, and we maximise this social utility, we always obtain an optimum that corresponds to a reduction in the production level.

This kind of example can be found in almost all text books on environmental economics and shows how the standard approach of environmental economics considers how functions of externalities behave. Environmental economists have however considered the possibility of non convex cost functions of externalities, but only in the cases when the cost is so high that the production of the victim disappears, and so the marginal cost becomes zero (Starret, 1972, Boisson, 1970, Burrows, 1995 Hanley et al, 1995)

Graph 1 Production and costs (monotone externality function)



Graph 2 Production and utility (monotone externality function)



A different problem which appears regarding relations between agricultural production and negative externalities pertaining to the particular form that functions of **physical** externalities may have. This is a completely different matter. What is understood by this is that some externalities may increase with production up to a certain level and thereafter decrease. Or vice-versa, decrease first and increase afterwards. In some cases, a decrease can be followed by an increase and then a new decrease may appear. And all this is expressed in strictly physical terms.

We provide two examples for nitrate pollution and soil erosion:

- **Nitrate pollution.**

In the case of nitrate pollution, it may happen that an increase in production originated from an increase in nitrogen fertilisation which produces more pollution. However, if at a certain point in time irrigation is introduced, combined with nitrogen fertilisation, an increase in production and in the quantities of nitrogen applied may be associated with a decrease in the pollution levels. This is strictly an agronomic problem, related to the Von Liebig hypothesis (Paris, 1992, Chambers et al, 1996, Berck et al, 2000) regarding the very low substitutability of some agricultural inputs. If one applies more and more nitrogen, production per unit of land will increase up to a point when another input becomes the limiting factor. At a certain level of production, an increase in nitrogen fertilisation produces a very low increase in production and high pollution. By applying water and more nitrogen, production will strongly increase, plants will use the new nitrogen added and a part of the one that was lost as pollution using lower quantities of nitrogen. If we continue to apply more and more fertiliser and water, production and pollution will continue to increase. In this case we are still moving along the same production function. Increasing irrigation does not imply a shift to another production function, as long as we are within the scenario of known technology. A shift towards a different production function can take place if new varieties or new irrigation methods are introduced. The changes in the proportion of factors used in the case we are considering are due to changes in relative prices, not in available technology.

In the situation described, we are facing a non-convex function of the physical externality. In this case, we are dealing with the production of one good. If we consider a farm, a region or the whole agricultural sector as a production unit, we will face a situation of joint production, and a change of relative prices, the introduction of a tax or a subsidy may change not only the techniques of a single product but also the production mix. Non convexities may arise even more easily (Flichman et al, 2002).

- **Soil erosion.**

A typical situation may appear within a certain range of production increase where the level of soil erosion decreases, and after a certain threshold it begins to increase. This is the case of a typical wheat-fallow rotation. As the soil remains without vegetation one year out of two, the level of soil erosion is high. If we change production methods to a technique of permanent wheat, the level of erosion will decrease, since the soil is covered by vegetation throughout the whole year. But if we increase production by a more intensive tillage, erosion and production will increase. Furthermore, if there is more fertiliser couples with more irrigation, production will once again increase and erosion will decrease (Plevne, 1999, Louhichi, 2001).

We need to introduce these technical characteristics of agricultural production in order to explain that the problem of defining the functional form of the physical externalities is not unpredictable, but related to basic characteristics of agricultural production.

This question of the functional form of agricultural externalities has important consequences in terms of policy implications and makes it more difficult to build agro-environmental indicators. We can see the problem with a simple example in which the function of the externality is a non-monotone one, as in the case where pollution increases up to a certain level of production and then decreases.

Let us assume that the cost function is the same we used in the previous example, but the function of the externality is different,

$$L = aY^2 + bY + c \qquad (11)$$

where:

$a < 0$

$b > 0$

$c > 0$

These emissions affect firm B with a unit cost C, total external cost is then

$CL = C(aY^2 + bY + c)$

In this case, this cost is a function that increases with the pollution level. However, the relationship between cost and production is more complicated. The external cost increases up to a certain level of production and afterwards it decreases. The marginal external cost decreases when production increases and after a certain point it has negative values.

In this case, social maximum utility will be

$PY - X - C(aY^2+bY+c)$ MAX (12)

$\Pi S_m = P - 2Y - 2aCY - bC = P - 2(1+ aC)Y - bC = 0$

$\Rightarrow \quad Y^* = (P-bC)/2(1+ aC) \quad \Rightarrow \quad Y^* - Y_0 = -C(b+Pa)$

We can deduce from this that the level of production maximising social utility may be higher, lower or equal to the one maximising private utility. The solution depends on the level of the price.

if $C < 1/a$;

Case 1 : $P < -b/a \Rightarrow \quad Y^* < Y_0$

Case 2 : $P > -b/a \Rightarrow \quad Y^* > Y_0$

Case 3 : $P = b/a \Rightarrow \quad Y^* = Y_0$

if $C > 1/a$;

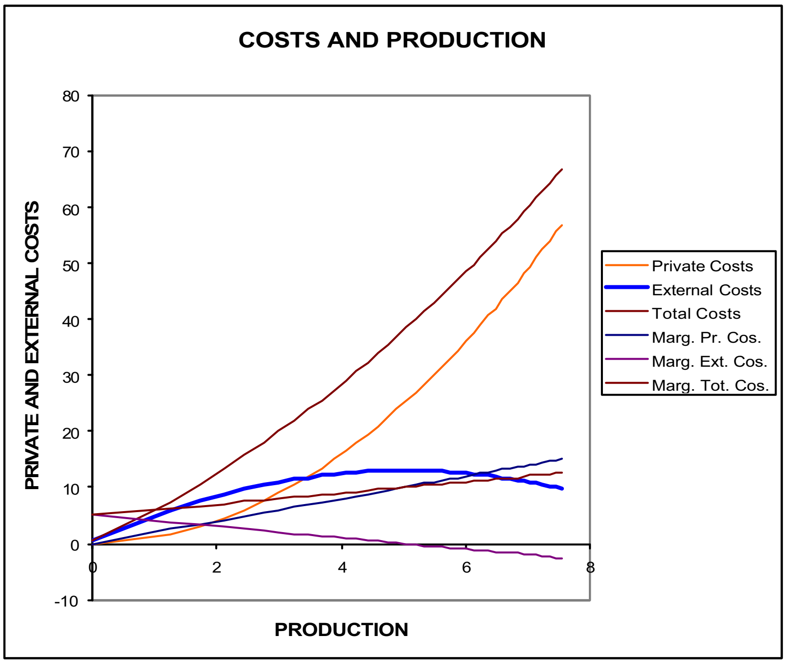
Case 4 : $P < -b/a \Rightarrow \quad Y^* > Y_0$

Case 5 : $P > -b/a \Rightarrow \quad Y^* < Y_0$

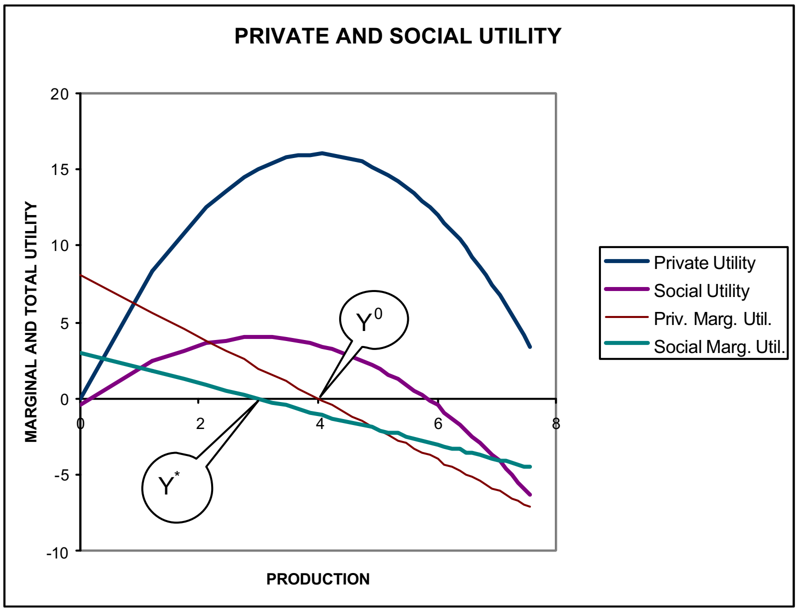
The policy implications of these results are relevant. In the first case, if we want to reduce the negative externality we should increase production and in the second case we should try to decrease it. Cases 4 and 5 are symmetric to 1 and 2.

In Graphs 3, 4 and 5 this situation can be easily appreciated.

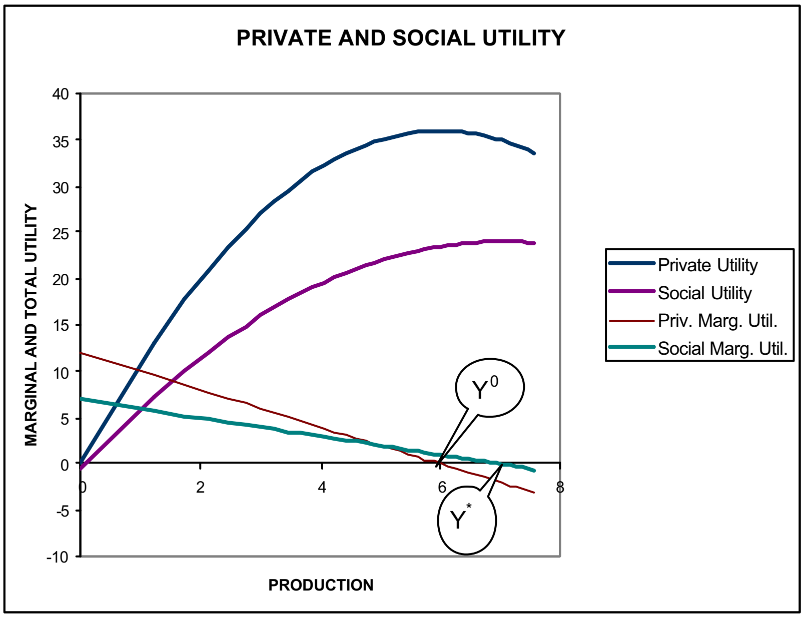
Graph 3 Production and costs (non-monotone externality function)



Graph 4 – Production and utility (non-monotone externality function, case 1)



Graph 5 Production and utility (non-monotone externality function, case 2)



In Graph 3 we see the shape of the external cost curve. This example is a stylised representation of empirical research work regarding the economic analysis of soil erosion in Turkey and in Tunisia (Plevne, 1999 and Louhichi, 2001).

Graph 4 shows the case when the optimum social level of production is lower than the private optimum, and Graph 5 shows the opposite situation. It is clear that if we are in an initial situation as the one represented by Graph 4, a policy targeting a diminution of the externality should be oriented towards a lower production level. But in a situation as the one represented by Graph 5, it is exactly the opposite. In that case, if trade liberalisation implies an increase in prices, we could face a situation in which production growth can lower the negative externality. This is a particular result in specific conditions, not a general argument. In other cases it could be exactly the opposite (as in the case of irrigated corn in Argentina, as mentioned before).

This example may be seen as just an amusing anecdote, but we believe it shows how complex the links between agriculture and the environment are. It is very clear that these links cannot be thoroughly represented through a straightforward relationship between levels of production and levels of environmental damage. The question that immediately arises is: What kind of information is required to deal with this problem? What are the tools that are available? In other words what is the *state of the art*? This is dealt with in the following section.

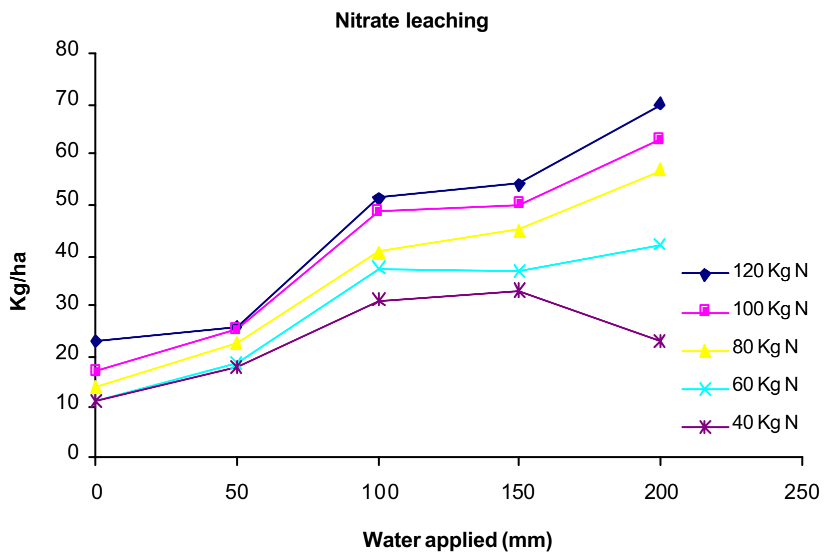
3. BUILDING PHYSICAL AGRICULTURAL PRODUCTION FUNCTIONS USING BIO-PHYSICAL MODELS

The information required to produce physical functions of agricultural externalities seems very difficult to obtain at first glance. Nevertheless, as we will see, using the tools available today, it is not really as difficult as it seems.

The primal approach to the representation of technology needs an engineering production function approach. Bio-physical models can be considered by the economist as a very detailed engineering production function. They allow for the representation of relationships between inputs and outputs, including externalities such as soil erosion, nitrate and chemical pollution, and salinity, among the possible outputs.

As an example, we plot in Graph 6 the level of nitrate leaching corresponding to the application of different amounts of water and nitrogen. This example was obtained out of a simulation of wheat production in the Italian Puglia Region using the CropSyst model.

Graph 6



Source: Farès (E.), 2002 Control Policies of Agricultural Pollution. Nitrate pollution in Apulia region. CIHEAM-IAMM Master of Science, Montpellier 2002.

Agronomic bio-physical models began to be developed in the 1970s. If we just consider pure biological phenomena, or input-output relations generated by nature, the engineering production function is just the mathematical expression of those relations. This is the case for bio-chemical relations transforming energy in biomass, which are the basis of bio-physical models. But agronomic bio-physical models simulate not only that type of process, but also the effects of technical activities typical of agricultural activities: type of tillage, level of fertilisation, irrigation, etc. The entire modelling of the technical, biological and physical process, with their inter-relations allows the development of these types of bio-physical models. These models are partially mechanistic and partially empirical. The mechanistic component is dominant in the more complex models. This means that the relation between the quantity of fertiliser used and the yields obtained, is explained by a series of cause-effect mechanisms, where the soil, the climate, the characteristics and variety of the plant are taken into account. It is far from being just a statistical regression based on experiments. The result is that these models are a physical detailed production function. The exogenous parameters are essentially those of the soil, the climate and the characteristics of the plant. Of course, the management (periods of seeding, periods and level of fertilisation and irrigation, etc) are also part of the exogenous parameters. But the basic mechanisms which define the relationship between fertiliser and yield are the same in any region inthe world.

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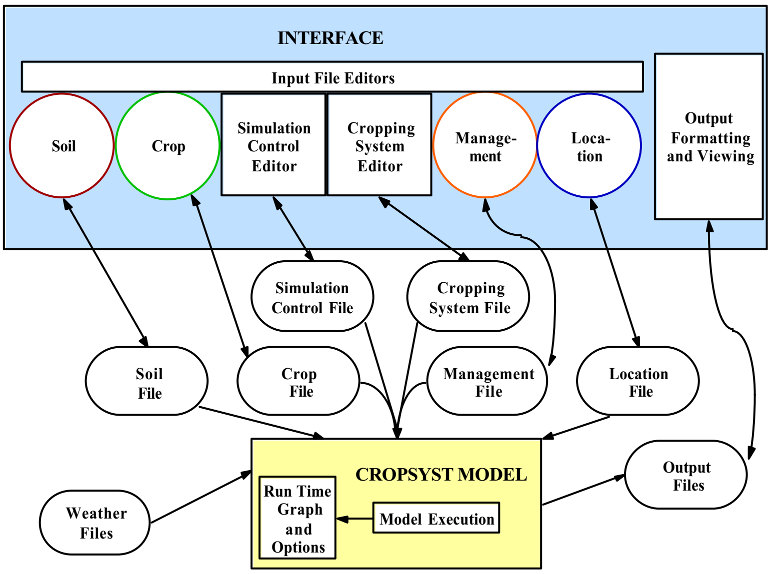
The first models of this type had been developed to simulate the growth of a single crop in a certain environment. The family of models CERES (Jones et al, 1986) is the best known example. In the 1980s, a new category of models appeared, allowing the simulation of crop rotations in a recursive way, incorporating the cumulative effects of agricultural activity on the soil conditions (erosion, fertility, water reserve in the soil, etc.) The best known models are EPIC (Williams et al, 1984, Cabelguenne et al, 1986); CropSyst (Stockle et al, 1996) and recently STICS (Brisson et al, 1998)

The following scheme gives an idea of the structure of a bio-physical model. We take the example of CropSyst, but other models are structured in a similar way.



We can easily appreciate that the amount of data required for running these models is quite important: weather information (on a daily basis), detailed soil data and crop parameters. However, this information is usually available for any region in the world. The problem is the lack of homogeneous information. Even in the case of the European Union, it is extremely difficult to obtain this data at a NUTS 2 level for all regions. In any case, the administrative regionalization is never representative of a soil-climate unit.

The integration of bio-physical and economic models for agricultural analysis began when the first agronomic bio-physical models were available. Previously, so-called "first generation" bio-economic models incorporated biological information (essentially related to population growth of fish and trees) in normative economic models, with the objective of optimising the use of a natural resource over time. These models use optimal control techniques to be solved and have a normative approach.

Some economists began to use these models as engineering production functions. The most usual technique applied to integrate the information provided by bio-physical models is to use the output of bio-physical models as an input in mathematical programming models. This can be achieved through technical coefficients of linear activities or using functions that have to be previously estimated (Vicien C, 1990). These functions obtained out of simulated "data" are usually called "meta-models" (Bouzaher et al 1993).

The first research work integrating bio-physical and economic models began in the USA, with an important support from the Department of Agriculture. This work was related to the analysis of economic impacts of soil erosion on long term agricultural activities. The results of this research was helpful to obtain the approval of the soil conservation regulations.

Later on, the focus was shifted to analyse diffuse pollution generated by agriculture (Mapp et al 1994, Bouzaher et al 1993 and 1995).

In Europe, the idea of integrating bio-physical and economic models was proposed by Flichman (1986) and the first application was a research on international comparisons of efficiency in agriculture (Flichman 1990). A large amount of research has been conducted in the last decade in this field in Europe and in other parts of the world. A bibliography on this specific field is incorporated as an appendix to this paper.

Most of the research work developed in this field in Europe is done at the farm level or at a regional level. In the United States, there is at least one project that has been developed at a national level (Atwood et al 2000). An Agricultural Sector Model for the USA is being coupled with the bio-physical model SWAT, in order to integrate issues such as water pollution and erosion in the Sector Model.

The agricultural sector model in development for the European Union, CAPRI model and its continuation, CAP-STRAT[33] integrates some environmental indicators produced by rough bio-physical models. Indicators of different pollutant emissions (greenhouse effect gases, nitrate emissions) are estimated according not only to the level of activity but also to the type of animal feed used. An indicator of water balances allows giving indications on the pressure on the resource in the regions where there are deficits as well as a weight to the nitrate emissions indicator. When we observe simultaneously a surplus in nitrates and in water, the pollution risk is more important.

But there are important limitations due to the lack of basic homogeneous information on essential items such as soil and climate.

Integrating information from bio-physical models could substantially improve the quality of important environmental indicators relating to agricultural production: nitrate pollution, chemical pollution, gases emissions, degradation of natural resources (soil, water), depletion of water resources, etc. But for the moment it is extremely difficult to go beyond regional case studies when using the best performing bio-physical models.

We observe two ways of assessing trade impacts on sustainability using bio-physical models:

To produce indicators that can be directly included in trade models. In some cases, as we established in the previous section, these indicators should be more complex than just a matrix of data relating directly to levels of activities to levels of emissions.

To interact with bio-economic models at a regional scale integrating information obtained with the bio-physical models. These models should use, as exogenous parameters, the results of trade models. If a trade model produces certain results in terms of price

[33] http://www.agp.uni-bonn.de/agpo/rsrch/capstr/capstr_e.htm

modifications, a regional model can use these price results as information and simulate impacts on environmental and natural resources.

These two ways of dealing with the problem should be considered as complementary. The first approach has the advantage of giving comparable information for all the regions considered in the trade model, but it has the disadvantage of using rather rough indicators. The second approach is better in terms of refined information, but it is impossible to use it for all regions in an acceptable manner.

4. SUGGESTIONS ON HOW TO DEVELOP THIS TYPE OF RESEARCH IN EUROPE

We will start this section showing the difficulties of the exercise, in order to suggest a set of actions. There are at least three different types of difficulties, namely data availability, aggregation issues and disciplines/specialities involved.

4.1. Data availability

Basic information required for bio-physical modelling is not easily available at the EU level for all regions. Major projects on climate and soil information systems have been produced, but when the time comes to obtain the required information, even for a Research Project funded by the European Commission, the "institutionalised systemic" difficulties are sometimes hard to overcome. Use of agro-chemicals is a field on which information is almost non-existent at a regionalized EU level. And chemical pollution generated by agriculture is certainly a most serious issue.

4.2. Aggregation issues

The appropriate level for studying the environmental impacts of changes in agricultural activities is the farm or the regional level, defining the region by its soil-climate characteristics. Dealing with trade, the level of analysis corresponds to countries or groups of countries. This difference of scale creates difficult methodological problems that should be solved. Of course, if we have to deal with administrative regions, the degree of precision for environmental assessment will decrease with the natural heterogeneity of the region and administrative accounting practices. Nevertheless, it may be useful to establish some rough indicators while being cautious about their inherent limitations. The only way to overcome this obstacle in a more rigorous way is to design in a coherent way regional case-studies that may allow an assessment of environmental impacts in specific situations. But this requires in terms of research organisation a unified framework.

4.3. Multidisciplinary approach

Using bio-physical models requires a well functioning cooperation with soil scientists, climatologists and agronomists. This type of cooperation is extremely difficult to establish and to maintain as institutional rigidities increase the difficulties. From an academic point of view, to cooperate with scientists of other disciplines usually does not pay off. Even from the point of view of research funding, the obstacles are quite important.

Available bio-physical models are not well adapted to be integrated in economic models. Some of them are too simple, as those elaborated by FAO for irrigation; others do not simulate the dynamic effects of rotations, being specific to one crop. The most complex are sometimes very well designed for research in soil science, or hydrology, or plant physiology, but they are not robust enough, which makes their application quite difficult. A good collaboration between economists and bio-physical modellers would rapidly improve the capacity of bio-physical models to be integrated in economic analysis. The type of bio-physical model required by the economists is not the most advanced from the point of view of agronomic sciences. But for the members of the agronomic disciplines, to adapt a model following the requirement of economists has no advantage in academic terms. This problem will remain an obstacle without creating specific incentives to solve it.

4.4. What can be done?

A possible action is to develop an institutional framework to facilitate the development of this type of multi-disciplinary activity. This framework could be a Research Project specifically designed to involve the different types of specialists that are required: International Trade Economists, Agricultural Economists and Bio-Physical scientists.

The difficult aspect is that multidisciplinary research of this type should be "dominated" by the economic dimension in order to be really productive. Dominated in the sense that bio-physical modelling should be adapted to the requirements of the economic modelling. And this is a very difficult task to carry out without a specific incentive to do so. Otherwise, each scientist will benefit from remaining within his/her own specific discipline. Experience in the past has shown on several occasions how scientific assessment have penalised researchers contributing to such multidisciplinary research.

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MODELLING THE EFFECTS OF TRADE ON WOMEN, AT WORK AND AT HOME: A COMPARATIVE PERSPECTIVE

Marzia Fontana

SUMMARY

The effects of trade on women vary by socio-economic characteristics, sector and country. This paper assesses how well such effects can be captured by a gendered social accounting matrix (SAM) and computable general equilibrium (CGE) model. The model is gendered in two ways: it distinguishes female from male labour and includes social reproduction (or housework) and leisure activities as sectors, in addition to standard market activities. These two extra sectors behave qualitatively like market sectors, but differ quantitatively from them, with social reproduction employing mainly women and being less responsive to price changes.

This model is applied comparatively to Bangladesh and Zambia. Bangladesh and Zambia have different resource endowments, with abundant labour in Bangladesh and abundant natural resources in Zambia. These differences are reflected in the sectoral composition of their foreign trade: in Zambia the main export is copper while in Bangladesh the main export is ready-made garments. The degree of the two countries' integration into world markets varies - with Zambia being more open than Bangladesh - and so does the female intensity of their traded sectors - with export sectors employing more women in Bangladesh than in Zambia. Gender relations in each country are shaped by different labour market institutions, systems of property rights and socio-cultural norms, thus making comparison interesting.

The main experiment in this paper describes the abolition of tariffs. Its gender effects appear overall to be more positive in Bangladesh than in Zambia. In Bangladesh women gain in terms of higher market employment and wages. Importantly, it is not only their absolute wages that increase, but also their wages relative to men. In Zambia, absolute income gains are smaller than in Bangladesh while the gender wage gap widens. In both Bangladesh and Zambia higher female market employment means that women spend less time on caring for families and leisure activities, with possible implications for overall welfare. This decline in non-market time is more marked in Zambia than in Bangladesh. In Bangladesh, the narrowing of the gender wage gap, and thus the increase in the opportunity cost of female workers' time relative to that of male workers, encourages some substitution of male for female labour in social reproduction, potentially leading to a more equitable allocation of tasks within the household.

The same experiment is also re-run with alternative parameter values to test the sensitivity of the results to different degrees of responsiveness of gendered aspects of the division of labour to economic change. The simulations show that higher price responsiveness of social reproduction and higher elasticity of substitution in production between male and female labour matter for the overall impact of tariff abolition, which is important to consider when designing policies. Other trade-related experiments, such as the introduction of an across-

the-board tariff of 20 per cent and an increase in the import price of food grains, are also analysed.

The paper concludes by comparing simulation results to other approaches in the gender-and-economics literature. It discusses strengths and limitations of the CGE methodology, and provides suggestions for further research.

ABSTRACT

The effects of trade on women vary by socio-economic characteristics, sector and country. This paper assesses how well such effects can be captured by a gendered social accounting matrix (SAM) and computable general equilibrium (CGE) model. The model covers not only all the sector of the market economy, but also household work and leisure, for women and men separately. It is applied comparatively to Bangladesh and Zambia to highlight how differences in resource endowments, labour market characteristics and socio-cultural norms shape the way in which trade expansion affects gender inequalities. The effects of tariff liberalisation appear to be more favourable in Bangladesh than in Zambia because of the higher female intensity of its export-oriented sector. The paper also compares simulation results to other approaches in the gender-and-economics literature, discusses strengths and limitations of the CGE methodology, and provides suggestions for further research.

JEL Classification: D58, J16, J22

Key Words: Bangladesh, Zambia, gender, trade, CGE models

MODÉLISATION DES EFFETS DU COMMERCE SUR LES FEMMES, AU TRAVAIL ET À LA MAISON: UNE ANALYSE COMPARATIVE

RÉSUMÉ

Les effets du commerce sur les femmes varient selon leurs caractéristiques socio-économiques, les secteurs et les pays. Dans cet article, il s'agit d'évaluer si de tels effets sont bien saisis au moyen d'une matrice de comptabilité sociale (MCS) désagrégée par genre et d'un modèle d'équilibre général calculable (MEGC). Le modèle prend en compte le genre de deux manières : il distingue la main d'œuvre féminine et masculine et ajoute la reproduction sociale (ou activités du ménage) et les activités de loisirs aux secteurs d'activités marchandes standard. Ces deux secteurs supplémentaires fonctionnent qualitativement comme des secteurs marchands, mais en diffèrent quantitativement, dans la mesure où la reproduction sociale emploie principalement des femmes et est moins sensible aux variations de prix.

Ce modèle est appliqué de façon comparative au Bangladesh et à la Zambie. Le Bangladesh et la Zambie ont des dotations en facteurs différentes, le Bangladesh disposant d'abondantes ressources en main-d'œuvre et la Zambie d'abondantes ressources naturelles. Ces différences se retrouvent dans la composition sectorielle de leur commerce extérieur : la Zambie exporte principalement du cuivre et le Bangladesh des vêtements de confection. Le degré d'intégration des deux pays au marché mondial est différent : la Zambie est plus ouverte que le Bangladesh. L'importance de la main d'œuvre féminine dans les secteurs d'exportation diffère elle aussi, ceux-ci employant plus de femmes au Bangladesh qu'en Zambie. Dans chacun des pays, les rapports sociaux entre hommes et femmes sont façonnés par l'organisation différente du marché du travail, les systèmes de droits de propriété et les normes socio-culturelles, rendant ainsi la comparaison intéressante.

La principale simulation décrite dans cet article porte sur l'abolition des tarifs douaniers. Ses effets sur l'inégalité des sexes paraît dans l'ensemble être plus positive au Bangladesh qu'en Zambie. Au Bangladesh, les femmes y gagnent en termes d'emplois marchands et de salaires. A noter que ce n'est pas seulement le montant absolu de leurs salaires qui augmente, mais aussi le montant relatif à celui des hommes. En Zambie, les gains en termes de montant absolu des revenus sont plus faibles qu'au Bangladesh, alors que l'écart de salaires entre les hommes et les femmes se creuse. Que ce soit au Bangladesh ou en Zambie, plus d'emplois féminins dans le secteur marchand signifie que les femmes consacrent moins de temps à s'occuper de leurs familles et à des activités de loisir, ce qui peut avoir des répercussions en termes de bien-être global. Cette diminution du temps consacré aux activités non marchandes est plus prononcée en Zambie qu'au Bangladesh. Au Bangladesh, la baisse de l'écart de salaires entre les hommes et les femmes accroît le coût d'opportunité du temps du personnel féminin relativement à celui du personnel masculin ; cela favorise dans une certaine mesure la substitution de main-d'œuvre masculine à la main d'œuvre féminine dans la reproduction sociale, ce qui conduit potentiellement à une répartition plus équitable des tâches à l'intérieur du ménage.

On a refait la même simulation en changeant les valeurs des paramètres de manière à tester la sensibilité des résultats à différents degrés de réactivité de la division du travail par genre aux changements économiques. Les simulations montrent qu'une sensibilité au prix plus élevée de la reproduction sociale et une élasticité de substitution plus élevée entre la main d'œuvre féminine et masculine dans la production ont leur importance pour l'impact global de l'abolition des tarifs douaniers : il faut le prendre en considération dans la conception des politiques économiques. D'autres simulations de politiques commerciales, telles que l'introduction d'un tarif uniforme de 20% et une augmentation du prix des importations de céréales alimentaires, sont aussi analysés.

L'article se conclut par la comparaison des résultats de ces simulations à ceux d'autres approches de la littérature économique sur le genre. Les forces et faiblesses de la méthodologie des MEGC sont discutées, et des suggestions sont apportées pour les recherches à venir.

RÉSUMÉ COURT

Les effets du commerce sur les femmes varient selon leurs caractéristiques socio-économiques, les secteurs et les pays. Dans cet article, il s'agit d'évaluer si de tels effets sont bien saisis au moyen d'une matrice de comptabilité sociale (MCS) désagrégée par genre et d'un modèle d'équilibre général calculable (MEGC). Le modèle couvre non seulement tout le secteur de l'économie marchande, mais aussi les activités domestiques et les loisirs, pour les femmes et les hommes séparément. Ce modèle est appliqué de façon comparative au Bangladesh et à la Zambie pour montrer comment les différences dans les dotations factorielles, les caractéristiques du marché du travail et les normes socio-culturelles déterminent la façon dont l'expansion commerciale affecte l'inégalité des sexes. Les effets d'une libéralisation tarifaire semblent être plus favorables au Bangladesh qu'en Zambie en raison d'une plus forte féminisation de l'emploi dans les secteurs d'exportation. L'article compare également les résultats des simulations à ceux d'autres approches de la littérature économique sur le genre. Les forces et faiblesses de la méthodologie des MEGC sont discutées, et des suggestions sont apportées pour les recherches à venir.

Classification JEL: D58, J16, J22

Mots-clefs: Bangladesh, Zambie, genre, commerce, modèles EGC.

MODELLING THE EFFECTS OF TRADE ON WOMEN, AT WORK AND AT HOME: A COMPARATIVE PERSPECTIVE[34]

Marzia Fontana[35]

INTRODUCTION

The effects of trade expansion on women in developing countries are mixed, differing by sector, geographical region, and socio-economic characteristics. A gender-aware approach to trade expansion would measure, first, the impact on women's current material status, given existing tasks and responsibilities under the gender division of labour – what in the literature has been termed 'practical gender needs' (Moser, 1989 and Molyneux, 1985). It should also aim to assess whether trade policies and outcomes contribute to more egalitarian gender relations, by reducing the basis of women's economic disadvantage and by modifying the gender division of labour in the labour market or in the household – what Molyneux and Moser would call 'strategic gender needs'. For example, a short-term increase in female market employment might address a practical gender need by providing women with new earning opportunities. The extent to which strategic gender needs would also be met would depend on the level and quality of that employment, on whether the jobs are regular, stable and safe and whether they would widen women's options.

Understanding how both practical and strategic gender interests are affected by greater exposure to trade would thus entail giving consideration to both short and long term changes in the labour market, in the household and in a range of other institutions– and to interactions among them. One would need to examine direct and indirect employment, price and income effects and also variations in access to resources. For instance, it would be important to assess not only whether women increase their income relative to men but also whether they gain greater control over it, what effect earnings have on women's own perceptions and on their social relations within the household and in the broader community. This would require taking into account not only objective but also subjective aspects of well being. Possible shifts in government spending and taxes resulting from trade liberalisation, as well as changes in risk and vulnerability of households, should also be given attention as these are likely to have gender-differentiated outcomes (for example

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when a reduction in tariff revenue affects the public provision of infrastructure and social services that are more frequently used by women).[36]

A variety of tools can be used to examine these dimensions – from econometrics to modelling to qualitative methods. Few studies of the differential effects of trade liberalisation on women and men employ general equilibrium models. Yet such models could be useful for gender analysis. They allow for linkages among actors and sectors and trace indirect effects under clear behavioural assumptions. Computable general equilibrium (CGE) models can be designed to include gender dimensions in various ways. Fontana and Wood (2000), for example, distinguish female from male labour and include household work and leisure as sectors in the SAM, in addition to standard market activities. This paper develops their work empirically and methodologically. The Fontana and Wood approach is applied to Bangladesh and Zambia. These two countries have different resource endowments, with abundant labour in Bangladesh and abundant natural resources in Zambia. Gender relations in each are shaped by different labour market institutions, systems of property rights and socio-cultural norms, thus making comparison interesting. The paper also compares simulation results to other approaches in the gender-and-economics literature, to identify methodological strengths and limitations.

Section 1 describes how a social accounting matrix (SAM) can be made gender-aware. It illustrates this with data sets from Zambia and Bangladesh that are then used for CGE model simulations analysed in Section 2. Section 3 analyses simulation results in the context of other non-modelling approaches. The paper concludes by suggesting improvements for future work.

1. COMPARISON OF SAMS

1.1. SAMs as tools for gender analysis

By describing all transactions between sectors and institutions in the economy (at one point in time), social accounting matrices are a useful tool for analysis of income distribution. The SAM framework is flexible enough to represent a wide range of socio-economic characteristics, thus allowing an understanding of diverse economic, social and cultural settings important for the design of policies.

The demand for integrated systems of social and economic statistics has been rising, and so have attempts to extend the conventional structure of the SAM to incorporate a larger number of indicators. This can be done by providing a greater level of detail for existing material contained in the traditional national accounts (for example by disaggregating further agricultural sectors into female-intensive crops and male-intensive crops, if the issue of concern is gender relations in rural settings) – what are called 'internal satellite accounts'– and/or by adding new data and extending definitions of what constitutes

[36] McCulloch,Winters and Cirera (2001) discuss these aspects in their chapter 4, but they do not highlight their implications for gender differences.

production or assets– what are called ‘external satellite accounts’. Examples of external satellite accounts are those which estimate environmental costs of production, and those that provide a valuation of household own activities.

Many of these SAM extensions can contribute significantly to understanding the gender effects of economic reforms, by providing better insights into the different roles of women and men in the generation and distribution of income and the interactions between households and the market economy. The development of satellite time-use modules, which keep a record of how much time people spend on various tasks and impute a monetary value to non-market time, spent either on household activities or on leisure, is of particular relevance to gender analysis.

As early as 1987 Pyatt recommended extension of SAM accounts by imputing value to time which is not explicitly marketed for financial remuneration. Pyatt notes that this would make a considerable difference to the welfare profile across socio-economic groups, especially from a gender perspective: ‘… since the economic activities of women are disproportionately concentrated on unremunerated activities, the present proposals would go a long way towards redressing the current practice of grossly discounting their contribution’ (1987:1).

To make these household services visible, beyond being important in itself, allows consideration of more constraints and interactions than with a standard accounting framework, particularly interactions between behaviour inside and outside the household which are crucial to understanding issues such as the response of female labour force participation to reform of economic policies. An accurate assessment of the gendered impact of economic policy changes also requires explicit consideration of time spent on leisure. This is because there are sharp differences in the extent of personal time between women and men and because changes in the market can alter the amount of time spent on rest and recreation, thus affecting welfare in ways that are overlooked in standard economic analysis. If two households have the same money income but in one its members have more personal time for leisure and relaxation, then there is an evident difference in their living standards, which should be taken into account in policy formulation.

Evaluations of this kind, however, are data-demanding and often methodologically difficult, which helps to explain why only a few countries to date provide satellite accounts regularly. Most are developed countries such as the Netherlands (Kazemeir et al, 1998), Australia (Ironmonger, 1999) and Canada. One notable exception among developing countries is India, for which SAMs have been constructed incorporating environmental concerns (Nugent and Sharma, 2002), the informal sector and gender disaggregation in the labour market (Sinha, 2000).

Most of the (few) available SAMs with gender features limit these to disaggregation of some sort of conventional accounts. For example, Nyanzi (2000) in a SAM for Uganda distinguishes household types not only by location and income level but also by the gender of the household’s head. This allows him to assess the gender implications of changes in both direct and indirect taxation, given that female-headed households and male-headed households appear to have markedly different sources of income and consumption patterns.

Fontana and Wood (2000) take the gender disaggregation of SAMs further. They not only distinguish factors, sectors and households by gender but also add estimates of social reproduction (or household work) and leisure to the standard accounting framework. This approach is used to extend two existing SAMs of Bangladesh and Zambia, which are compared in the following section.

1.2. Bangladesh and Zambia

Sub-Saharan Africa and South Asia are markedly different in their export structure, with Africa's exports heavily concentrated on primary products and South Asia's exports consisting mainly of labour-intensive manufactures. These differences largely reflect differences in the two regions' combination of human and natural resources relative to other regions: abundant natural resources and a low level of education in Africa and few natural resources and a low level of education relative to the supply of labour in South Asia (Wood and Mayer, 2001 and Mayer and Wood, 2001). Zambia and Bangladesh are no exception to these patterns. In Zambia the main export is copper, which constitutes almost 80 percent of total exports, while in Bangladesh the main export is ready-made garments (RMG), which provides over 60 percent of total foreign earnings. The Bangladeshi labour force is on average less educated than the Zambian one but the ratio of person-years of schooling to the country's land area is 40 times larger in Bangladesh than in Zambia.[37]

Traditionally, women's participation in market activities in Bangladesh has been low and confined to a narrow range of casual jobs on the margins of the labour market. However, since the establishment of the garment factories in the 1980s, significant changes in female labour force participation have taken place. These are documented in a rich literature (Kabeer, 2000, Sobhan and Khundker, 2001, Zohir, 1998, and many others). Women's contribution to agriculture is significant but still little studied, as women in this sector work mostly as unpaid family labour on activities carried out within the homestead.

Much of the analysis of women's issues undertaken in Zambia is concerned with the historical evolution of gender and economic relations in the context of gradual monetisation of the economy and of colonial policies which encouraged male labour migration to the cities and discouraged female migration, with a resulting increase of female-headed households in rural areas (Moore and Vaughan, 1993). Zambia has a high proportion of female-headed households, who face particular constraints as producers and are over-represented among poor small farmers. There is a strong dualism in men's and women's rights and responsibilities in Zambian agriculture. Non-staple food crops are women's sole

[37] In 1990 the ratio, with land area measured in square km, and years of schooling by average adult years of schooling multiplied by the number of adults, was 1100 for Bangladesh and 27 for Zambia: Wood and Mayer (2001) and Mayer and Wood (2001).

responsibility but most crops are grown with both male and female labour. In urban areas women are heavily concentrated in informal sector occupations.

The gendered social accounting matrices for Bangladesh and Zambia described in this section both refer to a similar time period, 1993 for Bangladesh and 1995 for Zambia. They were constructed by integrating existing data sets with additional information on the gender structure of the economy, both in the labour market and at the household level. The innovative feature of these two SAMs is the addition of social reproduction and leisure activities. Social reproduction includes services provided within households for own-consumption, which the standard System of National Accounts (SNA) defines as ‘economic’ but not ‘productive’ (UN 1993), such as: cooking and cleaning; care of children, the sick and the elderly; repairing the house, furniture and clothes; and personal, social and community support services. Leisure covers activities which the SNA defines as ‘non-economic’ (because they cannot be delegated to a third person) but excludes the minimum time needed for sleeping, eating, personal hygiene, and medical treatment (assumed to be 10 hours for both men and women).[38] The value added in the social reproduction and leisure sectors is estimated in the following way. First, the time spent by household members (of working age) on reproduction and leisure is calculated. The output in these sectors is then derived by valuing labour, for each skill and gender category, at its average market wage (considered to be the opportunity cost of each worker’s time), assuming that non-market sectors use neither capital nor land nor intermediate inputs (for further details on the SAMs and the limitations of this approach see Fontana, 2001 and Fontana, 2002).

Table 1 – Export composition and gender structure of the labour force in Bangladesh and Zambia (%)

	Bangladesh		Zambia	
	Total exports	Female market employment	Total exports	Female market employment
Primary products*	8.1	68.9	81.2	64.4
of which copper	0.0	0.0	78.4	0.3
Manufactures	91.9	11.2	8.6	6.3
of which garments	60.8	6.4	n.a.	n.a
Services	0.0	19.9	10.2	29.3
Total	100.0	100.0	100.0	100.0

Source: 1993 Bangladesh and 1995 Zambia gendered SAMs.
Notes: * SITC definition (includes processed primary).

Table 1 compares the export structure and the employment distribution of the female labour force in the two SAMs. It shows that exports are quite concentrated in both countries and that the proportion of the female labour force employed by the export sectors is higher in

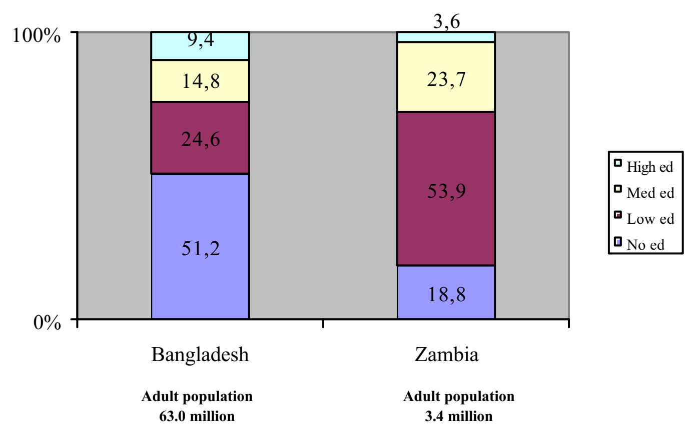
[38] Some studies, such as Zaman (1995) on Bangladesh, suggest that time spent eating and sleeping might also vary by gender. In these SAMs, however, for simplicity, differences in time spent on personal care by men and women are all captured by differences in leisure time.

Bangladesh than in Zambia. Manufactures constitute about 92 per cent of total exports in Bangladesh and account for about 11 per cent of female market employment. In Zambia, copper constitutes about 78 per cent of exports but employs less than one per cent of the female labour force. In both Bangladesh and Zambia more than 60 per cent of women work in agriculture, a sector with few exports (and probably, in both countries, with few prospects of becoming a leading export sector).[39] Women work also in services (30 per cent of the female labour force is in services in Zambia and 20 per cent in Bangladesh) but are mostly concentrated in sectors which are non-traded (trade and transport in Zambia and domestic services in Bangladesh).

Bangladesh is far more populous than Zambia, with an adult population of about 63 million compared with 3 million in Zambia. This big difference in the size of the two countries is reflected in their different degree of openness. The share of exports and imports in GDP is higher in Zambia (77 per cent) than in Bangladesh (20 per cent). Hence one would expect the impact of changes in trade policies on the domestic labour market to be smaller in Bangladesh than in Zambia.

On average the adult population is better educated in Zambia than in Bangladesh. More than 50 per cent of the working population has no education in Bangladesh while in Zambia the share of illiterates is only 19 percent, as illustrated in figure 1.

Figure 1 - Educational composition of the labour force

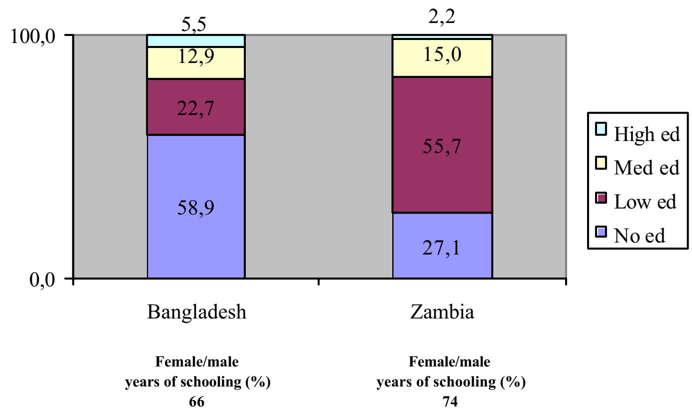


Source: 1993 Bangladesh and 1995 Zambia gendered SAMs.

[39] Some studies indicate that Zambia might have some advantage in the production of non-traditional agriculture and that women could benefit from it. However none of the experiments in this paper suggests the possibility of a significant expansion of female intensive agriculture, unless something drastic happens to the structure of the country.

The proportion of the workforce with primary or secondary education is 77 per cent in Zambia and 39 per cent in Bangladesh. The level of education of women is lower than that of the total population in both countries, as shown in figure 2. Although Bangladesh has a much larger share of its adult population with no schooling than Zambia, it also has a higher proportion of highly educated workers (9 per cent compared with 3 per cent in Zambia). For both reasons the Gini coefficient for educational distribution reveals greater inequality in Bangladesh (57.9) than in Zambia (27.4). The Gini coefficient for income distribution is however higher in Zambia (52.4) than in Bangladesh (28.3).[40] In Bangladesh the educational distribution of the adult population is more unequal not only across educational categories but also (though to a lesser extent) across genders: average years of schooling for women are about 66 percent of average years for men in Bangladesh, and 74 percent in Zambia.

Figure 2 - Educational composition of the female labour force



Source: 1993 Bangladesh and 1995 Zambia gendered SAMs.

Gender inequality is larger in Bangladesh than in Zambia also as far as wages are concerned. This is described in table 2. Women with no education, for example, earn less than 50 per cent of what men of the same group earn in Bangladesh compared with 65 per cent in Zambia. The gender wage gap narrows with tertiary education in both Bangladesh and Zambia, to 70 per cent and 95 per cent respectively. This information should however be taken with caution as reliable data on wages are not available. Wage estimates from various labour force surveys had to be adjusted in both SAMs to correct for discrepancies

40 Gini coefficients for educational distribution were calculated by the author (the illiterate were included in the calculations and assumed to have an average of three months of schooling) and Gini coefficients for income distribution are taken from Deininger and Squire (1998).

between value added data and employment data.[41] Other data (for example WISTAT data, UN, 1995) however seem also to indicate that gender wage inequalities are wider in Bangladesh than in Zambia. The smaller gap in earnings between female and male workers with university education can be explained by the fact that most highly educated women in both countries are employed by the public sector, where gender disparities in wages are less marked than in other sectors.

Table 2 – Female/male wage gap by educational level

	No education	Low education	Medium education	High education
Bangladesh				
Average female hourly wages as percentage of male wages	48	54	45	70
Market employment (million hours per year)				
Female	133	47	22	11
Male	302	184	113	84
Zambia				
Average female hourly wages as percentage of male wages	65	59	95	95
Market employment (million hours per year)				
Female	906	2471	232	36
Male	557	2365	814	106

Source: 1993 Bangladesh and 1995 Zambia gendered SAMs.

As shown in table 3, on average, the adult population of both Bangladesh and Zambia spend about 38 per cent of time on leisure and 62 per cent working. There are however differences between the two countries in how the work is distributed between the market and the household, with people in Bangladesh spending 28 per cent of the time on market work compared with 43 per cent in Zambia, and 34 per cent on social reproduction compared with 19 per cent in Zambia. These different patterns mainly reflect women's lower market participation in Bangladesh, which results in more time overall being devoted to household work. Men spend the same share of time on market work in the two countries (42 per cent) but enjoy more leisure in Zambia (52 per cent of total time compared with 42 per cent in Bangladesh). A possible interpretation is that, because of rigid socio-cultural norms that encourage women to stay within the homestead, in Bangladesh men are more likely to get involved in household tasks such as food shopping, or anything else that involves 'being seen'. Fafchamps and Quisumbing (1999) find this type of specialisation in rural Pakistan, where men dominate in 'outside' housekeeping tasks such as firewood collection or visiting the market.

[41] This is a common problem when constructing SAMs, since information for different accounts is derived from various sources which do not always use same definitions and measurements.

It is not certain whether the time allocation surveys for the two countries adopt the same definition of household work.[42] These different patterns, however, are consistent with other evidence on time allocation in South Asia and Sub-Saharan Africa. Studies reviewed in Ilahi (2000) show that in Africa women spend longer hours in both agricultural and non-agricultural activities than do men, while in Asia (and Latin America) the picture is one of a more marked gender division of labour, with men concentrating on income-generating work and women on housework.

Table 3 – Allocation of time between market and non-market activities (%)

Bangladesh	**Total**	**Female**	**Male**
Market	27.8	13.3	42.0
Social reproduction	34.4	53.2	16.1
Leisure	37.8	33.6	41.9
Total	100.0	100.0	100.0
Zambia	**Total**	**Female**	**Male**
Market	43.4	44.9	42.0
Social reproduction	18.5	32.9	5.7
Leisure	38.1	22.2	52.3
Total	100.0	100.0	100.0

Source: 1993 Bangladesh and 1995 Zambia gendered SAMs.

Comparison of table 3 with table 2 reveals another pattern: lower women's participation in market activities relative to men's is associated with a wider gender wage gap. It is not clear what is the direction of causation between these two facts - whether women spend more time on household work in Bangladesh because of higher wage discrimination in the labour market (which makes it less attractive for them to work outside their home), or whether the gender wage gap reflects stronger family norms that require women to perform more burdensome work at home, hence reducing their energy and flexibility in the job. Even if it were possible to determine that the initial reason for the wage differential was more on the supply side than the demand side, or vice versa, the observed differential is most likely to be a mixture of the two. Research on interactions between the household and the labour market is growing, but mostly limited to developed countries (for example Bonke, Gupta and Smith, 2002 on Denmark, Lazaro, Molto and Sanchez, 2002 on Spain and Anxo and Carlin, 2002 on France) where richer data on time use are available. These studies vary in their findings but, overall, suggest that, despite significant increases in female market participation, the gender division of labour within the household remains fairly unequal. Women's level of education and the availability of market substitutes for

[42] Estimating the allocation of women's and men's time between market and non-market activities was not easy, as data on time-use, in both Bangladesh and Zambia, are sparse and cover neither all tasks nor all geographical areas (no detailed time-use study was available for the urban areas, for example). Subsistence agriculture is included in market work.

household goods and services (such as utilities and child care) seem to be important determinants of the gender allocation of time.

Tables 4 and 5 show that the skill and gender composition of both market and non-market sectors varies between Bangladesh and Zambia. Of the two non-market sectors, social reproduction is somewhat more female intensive in Zambia (female time is 84 per cent of total labour time) than in Bangladesh (76 per cent of total). Moreover, while in Zambia social reproduction is more female intensive than any market sector, in Bangladesh there is one market sector, garments, which is more female intensive than social reproduction (83 per cent of total time is female).[43] The garment sector is also the most export oriented sector (88 per cent of its output is exported, as indicated in the third column of table 6) and one of the most labour-intensive sectors (labour accounts for 77 per cent of total value added as shown in the second column of table 6).

Table 4 – Educational and gender structure of SAM sectors, Bangladesh

	Shares of sectoral employment (% of female labour)				Females (%of total labour)
	No education	Low education	Medium education	High education	
Grains	59	26	12	4	17
Commercial crops	57	28	11	4	3
Livestock&horticulture	61	25	11	3	47
Fishing	36	17	28	19	29
Food processing	48	26	18	9	30
Garments	43	34	17	7	83
Other textiles	31	35	20	14	12
Other manufacturing	37	31	20	12	16
Infrastructure	48	27	12	13	5
Trade	30	29	24	18	5
Transport	56	26	11	7	1
Public services	5	8	17	70	20
Financial services	3	9	13	75	6
Domestic services	48	25	17	9	43
All market sectors	49	26	15	11	24
All social reproduction	55	23	14	8	76
All leisure	50	25	15	10	44
ALL	51	25	15	9	49

Source: 1993 Bangladesh gendered SAM.

Leisure is more male intensive in Zambia (only 27 percent of total leisure time is female) than in Bangladesh (female share is 44 per cent). Indeed, in Bangladesh leisure is more female intensive than most market sectors (with the exception of livestock and horticulture

[43] This is true also when social reproduction is considered by household type, with the sole exception of social reproduction in rural female-headed households, in which female time is 92 per cent of the total.

and, of course, garments). Conversely, in Zambia, most market sectors (except for mining, capital-intensive manufacturing, infrastructure and forestry) are more female intensive than leisure. The most female-intensive sectors in Zambia are the agricultural sectors, especially food and livestock (in which 70 per cent of total time is female) and horticulture and groundnuts (60 per cent). These sectors are the least skill-intensive sectors in the market economy in Zambia (although on average they are more skill-intensive than similar sectors in Bangladesh, reflecting the higher average educational level of the workforce in Zambia). Other relatively female-intensive sectors in Zambia are trade and transport, with female time being 51 per cent of total time. The same sectors in Bangladesh are very male intensive (less than 5 per cent of total time is female). Mining, which is by far the most open sector in Zambia (more than 93 per cent of its output is exported), is highly male intensive, with a female share in total time of only 7 percent. Mining is also the most capital-intensive sector (capital contributes 86 percent of total value added).

Table 5 – Educational and gender structure of the SAM sectors, Zambia

	Shares of sectoral employment (% of female labour)				Females (%of total labour)
	No education	Low education	Medium education	High eduction	
Maize	7	88	5	0	54
Commercial crops	6	94	0	0	41
Horticulture and groundnuts	19	54	24	4	60
Food and livestock	60	40	0	0	70
Fishing and forestry	12	78	10	0	7
Mining	10	45	41	4	7
Labour-intensive mfg	7	31	57	5	43
Capital-intensive mfg	43	49	7	1	4
Construction and utilities	20	80	0	0	3
Trade and transport	18	46	33	4	51
Public services	35	49	15	1	29
Market services	6	36	52	6	32
All market sectors	7	22	53	18	49
All social reproduction	20	65	14	2	84
All leisure	25	55	18	3	27
ALL	19	54	24	4	47

Source: 1995 Zambia gendered SAM.

Table 6 – Sectoral structure of Bangladesh and Zambia

	Net output (% of GDP)	Labour as share of VA (%)	Export intensity*	Import penetration*	Tariffs as share of imports (%)
Bangladesh					
Grains	8.8	54.8	-	2.3	12.5
Commercial crops	3.6	33.2	0.1	6.6	2.0
Livestock and horticulture	6.9	44.5	0.2	1.9	8.5
Fishing	2.8	6.3	10.0	-	-
Food processing	4.5	13.1	1.4	1.8	61.4
Garments	1.5	84.9	87.5	8.2	4.1
Other textiles	2.7	72.2	18.5	28.3	11.8
Other manufacturing	3.9	42.2	1.9	45.8	20.8
Infrastructure	12.2	17.5	-	-	-
Trade	16.7	76.6	-	-	-
Transport	14.5	35.4	-	-	-
Public services	12.2	32.2	-	-	-
Financial services	5.5	20.4	-	-	-
Domestic services	3.9	92.7	-	-	-
All market sectors	100.0	43.6	11.4	19.6	18.4
All social reproduction	36.6	100.0	-	-	-
All leisure	52.6	100.0	-	-	-
Total	189.2				-
Zambia					
Maize	4.3	69.5	4.3	15.0	3.1
Commercial crops	1.4	55.6	15.6	16.9	0.4
Horticulture and groundnuts	5.6	90.6	2.9	2.7	21.0
Food and livestock	6.7	80.7	1.9	4.7	18.6
Fishing and forestry	4.8	55.7	-	0.2	15.9
Mining	17.3	13.9	93.3	23.3	20.3
Labour-intensive manufacturing	9.6	51.7	4.0	13.0	11.8
Capital-intensive manufacturing	3.1	35.2	9.1	65.0	14.1
Construction and utilities	6.4	17.7	10.1	0.2	19.5
Trade and transport	20.6	57.9	-	7.7	13.4
Public services	7.3	77.1	-	-	-
Market services	13.0	52.8	8.6	25.2	13.4
All market	100.0	50.9	16.5	20.3	13.4
All social reproduction	20.8	100.0			
All leisure	67.8	100.0			
Total	188.6				

Source: 1993 Bangladesh and 1995 Zambia gendered SAMs.

Note: *Export intensity is measured as the share of exports in gross output and import penetration is measured as the share of imports in domestic use.

2. COMPARISON OF SIMULATIONS

The previous section has highlighted several differences between Zambia and Bangladesh. Although the two countries have similar production structures (particularly the shares of both agriculture and manufacturing in GDP, as can be seen in table 6), they differ in the sectoral composition of their foreign trade. The degree of their integration into world markets varies – with Zambia being more open than Bangladesh[44] (as shown in table 7, exports plus imports are 77 per cent of GDP in Zambia and 20 percent of GDP in Bangladesh) – and so does the female intensity of their traded sectors – with export sectors employing more women in Bangladesh than in Zambia. This mixture of human and natural resources are significantly different, and so are their patterns of distribution – with wealth inequalities being more marked in Zambia but gender inequalities in education and wages being higher in Bangladesh. It is to be expected therefore that same trade policies or shocks would have different gendered outcomes in the two countries.

Table 7 – Tariffs and openness (%)

	Bangladesh	Zambia
Average tariff rate	18.4	13.4
Tariffs as share of government revenue	30.7	30.0
Imports as share of GDP m.p.	12.1	41.0
Exports as share of GDP m.p.	7.5	36.1

Source: 1993 Bangladesh and 1995 Zambia gendered SAMs.

A computable general equilibrium model applied to the Bangladesh and Zambia SAMs is used to analyse the effects of changes in trade policies. The main experiment described in the first part of this section simulates the abolition of all tariffs. Both Bangladesh and Zambia have, on average, moderate levels of protection. As shown in table 7, the average tariff rate, measured by the ratio of total tariff revenue to total imports, is about 18 percent in Bangladesh and about 13 percent in Zambia. The same table also shows that tariffs constitute approximately 30 percent of total government revenue in both countries. However, as indicated in the last column of table 6, the degree of tariff dispersion is higher in Bangladesh, ranging from 2 per cent in commercial crops (which in Bangladesh are mainly jute, sugar and tea) to more than 61 percent for food processing (due to very high protection in the edible oil sector). In Zambia the tariff ranges from almost zero in commercial crops (cotton, sugar, tobacco and coffee) to 21 percent in horticulture and groundnuts.

[44] As noted in the previous section, this difference in openness is likely to be the result of 'natural' differences, such as population size, and might not be policy-driven.

In the second part of this section the simulation of tariff abolition is re-run with alternative parameter values to test the sensitivity of the results to different degrees of responsiveness of gendered aspects of the division of labour to economic change. Two other trade experiments are also analysed: the introduction of a uniform tariff and a higher import price of food grains.

The model follows the 'neoclassical structuralist' approach developed by Dervis, de Melo and Robinson (1982). A standard version of the model is documented in Lofgren et al. (2001), while the principles underlying its gendered application are discussed in Fontana and Wood (2000). A brief description of closures and exogenously specified elasticity parameters is provided in the following paragraphs.

The macro closures and the factor market closures, as well as the elasticities for factor substitution and foreign trade, are set the same for both Bangladesh and Zambia. This might not be 'realistic' but ensures that experiment outcomes are driven exclusively by differences in the initial socio-economic structure of the two countries (including their tariff system), rather than by differences in behavioural parameters.

It could be argued that behavioural parameters, by describing the ease with which systems adjust to change, are indeed an important component of a country's socio-economic structure. The aim of this paper is however to isolate the effects deriving from differences in sectoral composition of production and trade, and in factor distribution. Two other papers (Fontana, 2001 and Fontana, 2002) analyse experiments in which production, trade and consumption elasticities vary between Bangladesh and Zambia. Sensitivity analysis shows that initial shares are most important and that changes in elasticity values do not affect significantly simulation results.

The production function in the model is a three-level constant elasticity of substitution (CES) function. The substitution elasticity values for each level are listed in table 8. At the lowest level, for each educational category, female labour and male labour of the same skill are aggregated into composite labour. The ratio of female to male labour depends on the share parameter of this aggregation function, which differs across sectors, and varies with the wage rate of women relative to men, which induces substitution between them. To reflect the rigidity of gender roles, particularly within the household, female/male substitution is limited by setting the value of the elasticities to –0.5 in the market sectors and –0.25 in social reproduction and leisure.

The production function has an intermediate level which aggregates the four educational types of composite labour, with a substitution elasticity of –0.5, into one larger labour bundle. This larger labour bundle is the 'output' of the reproduction and leisure sectors, which in the SAM use neither capital nor land nor intermediate inputs. In the market sectors, however, the production function has an upper level which combines composite labour with capital and land to produce net output (which is then combined in fixed proportions with intermediate inputs to make gross output). The value of the substitution elasticity at the upper level varies by sector, ranging from –0.5 in agriculture to –0.8 in manufacturing and services.

Table 8 – Values of substitution elasticities in the CES production function

	Market			Non-market
Lower level (Labour by gender for each educational group)	0.5			0.25
Intermediate level (Labour by education)	0.5			0.5
	Ag	**Mfg**	**Sv**	
Upper level (Labour and non-labour factors)	0.5	0.8	0.8	-

The treatment of foreign trade in the model is such that buyers in each sector divide their expenditure between imports and domestically produced goods in shares which vary in response to changes in the ratio of domestic to import prices. Likewise, producers in each sector divide their output between the home and the export markets in shares which vary with the ratio of domestic prices to export prices. These CES import Armington functions and export CET functions partially insulate domestic prices from world prices, unlike more standard trade models in which the domestic prices of traded goods are strictly determined by world prices. As shown in table 9, the elasticity of substitution in both these functions is set at –2.0 in agriculture, –1.5 in manufacturing and –0.8 in services. [45]

Table 9 – Values of trade elasticities

	CET	Armington
Agriculture	2.0	2.0
Manufacturing	1.5	1.5
Services	0.8	0.8

As for the macro closures, the balance of trade is fixed and the level of exports and imports adjust through changes in the real exchange rate. Government consumption in each sector is fixed in real terms, as is the demand for investment goods. The savings-investment balance is achieved through adjusting the household propensity to save. The government account balance is achieved through adjusting direct tax rates. It is assumed that loss of revenue from imports is fully recovered by introducing higher direct taxes. In the simulations described in this paper the government increases the income tax rate by a uniform number of percentage points for all income recipients, hence spreading the burden uniformly across households and enterprises. Alternative government account closure rules would be possible. For example, assuming increases in indirect taxes (as often recommended to developing countries by the international financial institutions), or flexible government

[45] Elasticity values of –0.8 are considered 'medium low', -1.5 'medium high' and –3.0 'high' (Sadoulet and de Janvry, 1995).

consumption, would lead to important differences in the distributional effects of trade liberalisation, in terms of both income and gender.[46]

As for the factor market closures, the assumption is that the supply of capital and land in each sector is fixed, but labour is mobile, so that supply to each sector responds freely to demand, within limits set by the fixed total supplies of female and male labour. Alternative rules in the labour market could be also modelled. For instance, wage determination mechanisms that reflect bargaining between workers and employers (Taylor, 1989)–-with differences in power between male and female workers–- or various kinds of rationing could be relevant for gender analysis. The implications of alternative closures for simulation results will be examined in future work. Other features of the Bangladesh and Zambia models used in this paper are the same as in the models described in Fontana (2001) and Fontana (2002) respectively.

The simulation results described in the following pages are analysed with particular attention to: (i) changes in the allocation of female labour between employment in the market economy (and among its different sectors), social reproduction and leisure and (ii) the female wage rate, both absolute and relative to male wages. While the labour categories are identical in the two countries, the classification of production sectors and household types differs between them. To make comparison of results easier, changes are often reported for aggregated categories.

2.1. Abolition of tariffs

When all tariffs are removed, the total volume of imports increases by 3.5 per cent in Zambia and by 14.7 per cent in Bangladesh. Imports increase the most in manufacturing, but also in female-intensive agriculture in Zambia, and in manufacturing other than garments in Bangladesh, as these were previously the most protected sectors. In both cases the trade balance is restored by a depreciation of the exchange rate, which is greater in Zambia (7.6 percent) than in Bangladesh (0.6 percent). This has partly to do with the supply elasticity of the export sectors, which is greater in Bangladesh than in Zambia because of the much larger share of labour value added in garments as compared with mining. Since the assumption in the model is that labour is a mobile factor while the supply of capital and land in each sector is fixed, a sector that uses large inputs of labour relative to land and capital is able to increase more easily its output in response to price changes.[47]

[46] Given that the model used in this paper is a single-period model, a closure combining fixed foreign savings, fixed real investment and fixed real government consumption seemed to be preferable for simulations that explore the equilibrium welfare changes of alternative policies. A closure with flexible foreign savings or flexible investment would lead in this context to misleading results. For example, decreases in investment would raise household welfare, but the short-term static nature of the model would not allow consideration of welfare losses in later periods that might arise from a smaller capital stock.

[47] The sectoral price elasticity of supply is given by $\varepsilon_i = \sigma_i * \theta_{iL}/\theta_{iK}$, where σ_i is the elasticity of substitution in production between factors and θ_{iL} and θ_{iK} are the factor shares for labour and capital or,

As a result of the exchange rate depreciation, exports rise in both countries, mainly in garments in Bangladesh, and in mining and in male-intensive agriculture in Zambia.

These changes in exports and imports cause domestic market output to increase in both countries by about 0.5 percent. The results by sector are presented in table 10. The sectors which expand the most are manufacturing in Bangladesh and mining in Zambia. Within the Bangladesh manufacturing sector, it is garments that rise while food, beverages and tobacco, and other manufacturing decline. Manufacturing in Zambia is unchanged, because of offsetting changes in the capital-intensive sector, which declines, and in the labour-intensive sector, which slightly increases. Agriculture (mainly grains) declines marginally in Bangladesh while it increases in Zambia, due to higher production of male-intensive commercial crops and maize, while output in both female-intensive sectors - food staples and horticulture – falls.

Table 10 – Effects of tariff abolition on output
(percentage changes from the base case)

	Bangladesh	Zambia
Market, of which:	0.5	0.6
Agriculture	-0.2	0.4
Mining	-	1.8
Manufacturing	3.2	0.1
Services	0.2	0.4
Social reproduction	-0.2	-0.3
Leisure	-0.3	-0.7

Source: Model simulations.

The corollary of higher market production is an output fall in social reproduction and leisure. The effect of tariff elimination is to reduce the average price of traded relative to non-traded goods and services. Hence, in both countries, market sectors expand and non-market sectors, being non-traded, contract. The decline is higher in leisure than in social reproduction, since the consumption of leisure is more responsive to price changes than that of household work. Leisure, a male-intensive activity, declines in Zambia more than in Bangladesh, because its opportunity cost increases more in the former country than in the latter, reflecting a larger rise in male wages. The increase in total output (both market and non-market) is 0.2 percent in Bangladesh and negligible in Zambia.[48]

more generally, for the mobile factor (L) and the fixed factor (K) (Dervis, de Melo and Robinson, 1982: 264).

[48] Under the assumption of full employment of all factors, changes in total output from simulations can only be slight. A small increase in output could be the result of reallocation of resources from less productive sectors to more productive ones. A wage distortion term called WFDIST is included in the model to capture possible wage differences across activities for the same labour category that might result from various market distortions. WFDIST measures the extent to which the sectoral marginal revenue

Because of the different gender composition of the expanding and contracting sectors in the two countries, the increase in female market labour force participation in the experiment is larger in Bangladesh than in Zambia and so is the rise in female wages. Effects across educational groups also vary between the two countries.

Employment in the garment sector in Bangladesh rises by about 37 per cent for both women and men, but the absolute increase is higher for women than for men, because of their much larger initial share. Reflecting the educational composition of the garment sector's female labour force, the increase in market employment is largest for women with primary and secondary education (about three per cent), and less significant for the highly skilled (two per cent). Market participation of uneducated female workers rises only by one per cent, as the increase in their garment employment is partly offset by a decline in their time inputs in grain production. A shift in employment from agriculture to the manufacturing sector could have potentially significant positive effects, even when net increases in participation are slight, as this sector generally offer better working conditions than agriculture. Time spent in social reproduction by women with primary and secondary education declines on average by about 0.4 per cent, while their leisure time declines more. A similar pattern, although smaller in magnitude, can be observed for female workers with both higher education and no education. Because the abolition of tariffs causes a significant expansion of the most female-intensive sector in the Bangladesh economy, the economy-wide demand for female labour rises more than the demand for male labour, and hence the wage rate of women increases both absolutely and relative to men. The rise is largest for women with primary and secondary education. Their wage increases by about three per cent in absolute terms, and by two per cent and one per cent respectively relative to that of men with similar skills. These results are described in table 11.

Because the elimination of tariffs on traded market goods raises the average demand for market goods relative to non-market goods, female market employment rises in Zambia too, and so does the female wage rate, but by a smaller proportion than in Bangladesh. An important difference, however, is that in Zambia the gender wage gap widens, instead of narrowing as in Bangladesh. This is because mining and commercial crops, the sectors that expand the most as a result of tariff elimination in Zambia, are male intensive.

product of the factor deviates from the average return across the economy. Manufacturing is more productive than the average (WFDIST >1) in Bangladesh and so is mining in Zambia, but agriculture is less productive than the average (WFDIST<1) in both countries.

Table 11 – Effects of tariff abolition on employment and wages, Bangladesh (percentage changes from base case)

	Female no education	Female primary education	Female secondary education	Female high education	Total female	Total male[49]
Employment						
All market sectors, of which:	**1.4**	**3.1**	**3.4**	**2.2**	**2.1**	**0.3**
Grains	-1.7	-2.0	-1.9	-1.7	-1.8	-1.4
Commercial crops	1.7	0.0	1.5	1.7	1.6	2.0
Livestock and horticulture	0.2	-0.1	0.0	0.2	0.1	0.5
Fishing	0.6	0.3	0.3	0.6	0.5	0.8
Food processing	-2.8	-3.1	-3.0	-2.8	-2.9	-2.6
Garments	36.8	36.4	36.5	36.8	36.6	37.1
Other textiles	10.5	10.2	10.2	10.5	10.4	10.7
Other manufacturing	-13.0	-13.3	-13.2	-13.0	-13.1	-12.9
Infrastructure	0.2	-0.1	-	0.2	0.2	0.4
Trade	0.5	0.2	0.2	0.5	0.4	0.7
Transport	0.7	0.4	-	0.7	0.6	0.9
Public services	0.2	-0.1	-0.1	0.2	0.1	0.3
Financial services	-	-0.1	0.0	0.2	0.1	0.3
Domestic services	0.0	-0.4	-0.3	-0.1	-0.1	0.1
All social reproduction	**-0.2**	**-0.4**	**-0.4**	**-0.2**	**-0.3**	**-0.1**
All leisure	**-0.3**	**-0.5**	**-0.5**	**-0.4**	**-0.4**	**-0.3**
Hourly wages						
Absolute	1.8	2.9	2.5	1.7		
Relative to males*	0.9	1.8	1.4	0.5		

Source: Simulation results.

*This is the difference between the absolute percentage change for females and the absolute percentage change for males. A positive value indicates that the female/male wage gap has narrowed.

The increase in market labour force participation in Zambia is small on average (about one per cent) for all educational groups. Employment rises the most (1.1 per cent) for female workers with no education, because of expansion of commercial crops, and for women with secondary education, whose largest sectoral increase is in mining. While for this latter

[49] The percentage increase in total female market time is significantly higher than the increase in total male market time despite the fact proportional changes in specific sectors are rather similar for the two categories of workers. This is due to different weights between them: more than 8 per cent of total female market time is spent in garments and other textiles (the sectors that expands the most) while only a negligible share of total male time is used by these sectors. The extent to which male time substitutes for female time in each sector in response to changes in relative wages (about 0.3 per cent) might appear rather small. However these aggregate results mask differences across educational categories.

group the rise in market participation is entirely at the expense of their leisure, with only a negligible change in time spent on household work, for the former the decline in non-market time is by 0.5 in social reproduction and by more than one per cent in leisure. Although social reproduction and leisure decline on average, there are differences between some (rich) households, where non-market time rises, and other (poor) households, where it falls. Women of the same skill experience either a decline or a rise in their time inputs on household work and leisure, depending on the type of household they belong to.[50] It is because in Zambia women with higher education are concentrated in rich households, while women with less education mainly belong to poor ones, that the decline in female non-market time is larger for the latter than for the former.

The impact on wages too differs between these two groups of female workers, with gains being smaller for the higher educated. Women with secondary education are in fact the ones for whom wages increase the least in absolute terms (0.4 per cent) and decline the most (1.1 per cent) relative to men. This is because the sectors that expand in the experiment on average use uneducated female labour more intensively than secondary educated labour. As for other categories of female workers, employment rises by 0.4 per cent for women with primary education, while their wages increase by 0.8 percent in absolute terms but fall by 0.5 per cent relative to men. Employment of women with tertiary education increases by 0.6 per cent and their wages by 1.0 per cent. The results are reported in table 12.

Changes in the functional distribution of income favour female labour over male labour and labour over land and capital in Bangladesh, while in Zambia non-labour factors gain more than labour factors, and capital gains more than land.

To conclude, the gender impact of tariff abolition appears overall to be more positive in Bangladesh than in Zambia. In Bangladesh women gain in terms of higher market employment and wages. Importantly, it is not only their absolute wages that increase, but also their wages relative to men. In Zambia, absolute income gains are smaller than in Bangladesh while the gender wage gap widens. Thus, in Bangladesh, outcomes are favourable not only because a ‘practical’ gender interest (an increase in the total female wage bill) is satisfied, but also because an opportunity arises for a ‘strategic’ gender interest to be met (through redressing the gender imbalance in economy-wide wages). In both Bangladesh and Zambia higher female market employment means that women spend less time on caring for families and leisure activities. This decline in non-market time is more marked in Zambia than in Bangladesh. In Bangladesh, the narrowing of the gender wage gap, and thus the increase in the opportunity cost of female workers’ time relative to that of male workers, encourages some substitution of male for female labour in social

[50] Differences among households are not discussed in detail in this paper. Household-disaggregated results for this experiment are available on request. Fontana (2001) and Fontana (2002) analyse this aspect for other simulations.

reproduction, potentially leading to a more equitable allocation of tasks within the household.[51]

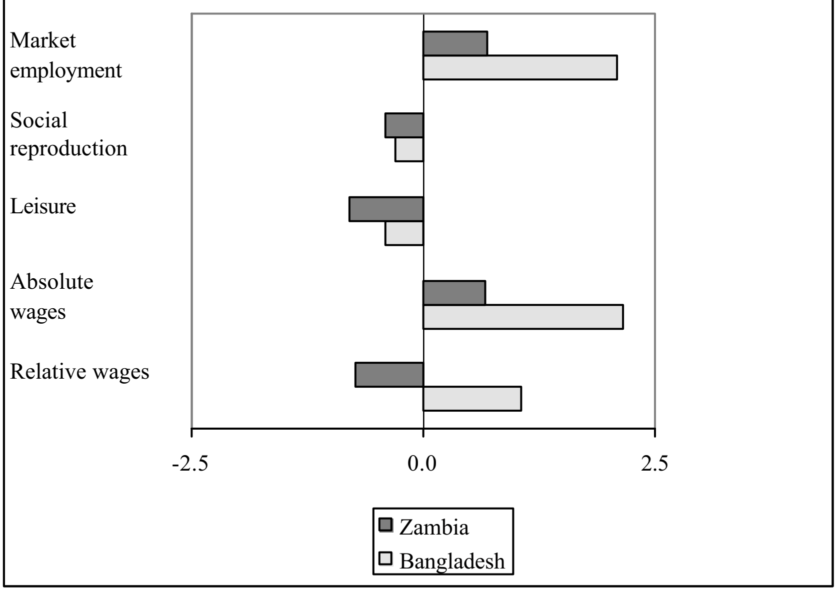
Table 12 – Effects of tariff abolition on employment and wages, Zambia (percentage changes from base case)

	Female no education	Female primary education	Female secondary education	Female high education	Total female	Total male
Employment						
All market sectors, of which	**1.1**	**0.4**	**1.1**	**0.6**	**0.7**	**1.1**
Groundnuts & horticulture	0.0	0.1	-	-	0.1	-0.2
Commercial crops	6.7	0.0	-	-	6.7	6.4
Food & livestock	-0.4	-0.3	-	-	-0.3	-0.6
Fishing & forestry	0.6	0.8	1.0	0.7	0.8	0.5
Maize	2.3	2.4	-	-	2.4	2.1
Infrastructure	5.7	5.8	6.0	5.7	5.9	5.5
Mining	13.8	14.0	14.2	13.9	14.1	13.7
Labour-intensive manufacturing	0.8	0.9	1.1	0.8	0.8	0.5
Capital-intensive manufacturing	-1.8	-1.7	-1.5	-1.8	-1.6	-2.0
Market services	0.9	1.0	1.2	0.9	1.1	0.7
Trade & Transport	0.5	0.6	0.8	0.6	0.6	0.3
Public services	0.1	0.2	0.4	0.1	0.3	-0.1
All social reproduction	**-0.5**	**-0.4**	**0.0**	**-0.1**	**-0.4**	**-0.4**
All leisure	**-1.1**	**-0.9**	**-0.4**	**-0.2**	**-0.8**	**-0.8**
Hourly wages						
Absolute	1.0	0.8	0.4	1.0		
Relative to males	-0.8	-0.5	-1.1	-0.3		

Source: Simulation results.

[51] This happens because the model assumes that the world works in a 'Beckerian' way. According to Becker (1965), an increase in the market value of women's time of a sufficient magnitude would bring about a re-allocation in the division of labour with women increasing their time into market-oriented activities while men reallocated some of their time into domestic or other non-paid uses of their time. In reality, the intra-household division of labour might not be very responsive to economic incentives because many aspects are governed by strong social and cultural norms. Estimates of the relative role of economic incentives and social customs in determining the allocation of household work (for example, Fafchamps and Quisumbing, 1999, on rural Pakistan) show that both are important. A way of representing this in the current model is to vary the elasticity of substitution between male and female labour in non-market activities or the price elasticity of demand for social reproduction.

Figure 3 - Effects on female percentage changes in employment and wages (average across all educational groups)



2.2. Other experiments

Once the investment of constructing a model has been made, a large number of experiments of many kinds can easily be undertaken. In this section, four more simulations are described. Two are variants of the main experiment analysed in section 2.1. The first experiment increases the price elasticity of social reproduction as a proxy for greater responsiveness of the consumption or output of social reproduction to changes in its relative price (and hence more flexibility in the allocation of women's time). The second simulation increases the elasticity of substitution in production between male and female workers in both the market and the household to explore the effects of greater responsiveness of the mixture of female and male workers to changes in their relative wages. The other two simulations in this section analyse different sorts of trade changes: the third experiment simulates the introduction of an across-the-board tariff of 20 per cent and the fourth simulates an increase in the import price of food grains.

2.2.1. Higher price elasticity of demand for social reproduction

In this version of the main experiment the price elasticity of demand for social reproduction is set close to – 1.0, compared to –0.3 in the main experiment in Zambia and –0.5 in Bangladesh.[52] The main effect of higher responsiveness of consumption of social

[52] The relationship between different parameters and elasticity values in the Linear Expenditure System (LES), is quite rigid. Changing the price elasticity value for one commodity involves changing all other

reproduction services to changes in their relative price is that women's non-market time declines more in social reproduction and less in leisure, compared with the main experiment. The higher elasticity of demand for household work permits a larger outflow of female labour from social reproduction both in Bangladesh and in Zambia, but the way in which women's time released from the household is reallocated to other activities varies between the two countries, depending on the female intensity of their other sectors, both in the market and the non-market sphere. As shown in tables 13 and 14, in Zambia the main effect is to make the increase in female market participation larger, especially for women with no education and with primary education, who work mainly in agriculture. Their involvement in crop production is higher than in the main experiment and, as a result, output in this sector rises more. On average, however, gains in female wages are smaller than in the main experiment, and the gender wage gap widens more. In Bangladesh, the main effect is to allow the outflows from leisure to be smaller. The increase in market participation is smaller too, especially for semi-skilled women (with primary and secondary education), who constitute the majority of workers in the garment sector. For these workers, gains in absolute wages are about the same as in the main experiment but the gender wage gap narrows less. Because of the smaller increase in manufacturing, market output rises slightly less than in the main experiment, social reproduction declines more and leisure falls less.

Table 13 – Effects of higher demand elasticity for social reproduction on output (percentage changes from the base case)

	Bangladesh	Zambia
Market, of which:	0.4	0.6
Agriculture	-0.3	0.5
Mining	-	1.8
Manufacturing	2.7	0.1
Services	0.2	0.4
Social reproduction	-0.3	-0.5
Leisure	-0.1	-0.6

Source: Simulation results.

Since women appear to be more 'time-poor' in Zambia than in Bangladesh (recall from table 3 that leisure constitutes 22 per cent of women's time in Zambia and 34 per cent in Bangladesh), one would have hoped to see a more significant effect (i.e. a much smaller decline of) on women's leisure in Zambia, from simulating a higher elasticity of demand for their household work. This however could have not been expected given the model structure. Because in Zambia commercial crops and maize, the production of which increases as a result of tariff abolition, are more female intensive than leisure, most of the female time released from social reproduction is spent on working more in agriculture. Conversely in Bangladesh, because leisure is more female intensive than most market sectors, the time freed up from household work mainly attenuates the decline in leisure.

price and income elasticities for each household type, to satisfy Engel's law (sum of marginal budget shares must be equal to one). The new value of the price elasticity for social reproduction in both countries was chosen so as to keep adjustments to other parameters within a reasonable range.

Table 14 – Effects of higher demand elasticity for social reproduction on female market participation and wages (percentage changes from the base case)

	Female no education	Female primary education	Female secondary education	Female high education	Total female	Total male
Bangladesh						
Market employment	1.2	2.8	3.2	2.4	1.8	0.1
Social reproduction	-0.3	-0.5	-0.5	-0.5	-0.4	-0.2
Leisure	-0.1	-0.2	-0.3	-0.1	-0.1	0.0
Wages						
Absolute	1.9	2.9	2.4	1.3		
Relative to males	0.9	1.7	1.1	-0.1		
Zambia						
Market employment	1.3	0.6	1.1	0.5	0.8	1.1
Social reproduction	-0.8	-0.6	-0.1	-0.1	-0.6	-0.6
Leisure	-1.0	-0.8	-0.4	-0.2	-.0.7	-0.8
Wages						
Absolute	0.8	0.6	0.3	1.1		
Relative to males	-1.1	-0.8	-1.2	-0.3		

Source: Simulation results.

2.2.2. Higher elasticity of substitution in production

In this variant of the experiment, the elasticity of substitution between male and female workers, for each skill category, is increased from -0.5 to -2.5 in all market sectors and from -0.25 to -1.25 in all non-market sectors. In Zambia there are no significant differences in sectoral output changes compared with simulation 2.1. The higher substitution elasticity causes a marginally higher rise in total market participation for women with no education and women with secondary education, while the effect on market participation for women with primary and tertiary education is unchanged. Women with no education and secondary education experience also a larger decline in social reproduction time while the decline in leisure is the same as in the previous experiment. In Bangladesh, too, differences from the main experiment, in terms of both output changes and female market force participation, are slight. Changes in market participation for women with no education and secondary education are the same as in the main simulation. Market employment increases marginally less for women with primary education (while their leisure time declines more) and more for women with higher education.

Table 15 – Effects of higher elasticity of substitution in production on output (percentage changes from the base case)

	Bangladesh	Zambia
Market, of which:	0.5	0.6
Agriculture	-0.2	0.4
Mining	-	1.8
Manufacturing	3.2	0.1
Services	0.2	0.4
Social reproduction	-0.2	-0.4
Leisure	-0.3	-0.7

Source: Simulation results.

Table 16 – Effects of higher elasticity of substitution in production on female market participation and wages (percentage changes from the base case)

	Female no education	Female primary education	Female secondary education	Female high education	Total female	Total male
Bangladesh						
Market employment	1.4	3.0	3.4	2.3	2.0	0.3
Social reproduction	-0.1	-0.4	-0.3	-0.2	-0.2	0.0
Leisure	-0.4	-0.6	-0.5	-0.4	-0.4	-0.3
Wages						
Absolute	1.5	2.4	2.1	1.6		
Relative to males	0.5	1.0	0.8	0.3		
Zambia						
Market employment	1.2	0.4	1.2	0.6	0.7	1.1
Social reproduction	-0.6	-0.4	-0.1	-0.1	-0.4	-0.5
Leisure	-1.1	-0.8	-0.4	-0.2	-0.7	-0.8
Wages						
Absolute	1.3	1.0	0.9	1.1		
Relative to males	-0.2	-0.1	-0.3	-0.1		

Source: Simulation results.

Even though these changes are slight, it is possible to note some dissimilarity between Bangladesh and Zambia, particularly as regards patterns across educational categories. In Bangladesh, the higher elasticity of substitution affects female workers with primary and tertiary education, but hardly alters the impact on women with no education and secondary education. Conversely, in Zambia, it is these two latter categories which are most affected, while the effects on female workers with primary and tertiary education are unchanged compared with the main simulation. These differences can be explained by the different wage patterns by level of education in the two countries.

To sum up, the variants of the main experiment described in sections 2.2.1 and 2.2.2 show that higher price responsiveness of social reproduction and higher elasticity of substitution in production between male and female labour matter for the overall impact of tariff abolition.[53] These elasticities are determined by a variety of social and cultural factors. The effects of changing them can be positive or negative for gender equality, depending on the gender composition of the non-market sectors relative to market sectors, and on the extent and nature of the gender wage gap.

2.2.3. Uniform tariff of 20 per cent

The introduction of an across-the board tariff of 20 per cent, just above the average tariff rate in the two countries, was also simulated. Uniform taxation has the effect of making protection higher in sectors with previously low tariffs and lower in sectors with previously high tariffs. In both Zambia and Bangladesh the least protected sector is agriculture– especially commercial crops (coffee, cotton, tobacco and maize in Zambia and jute, tea and sugar in Bangladesh) while vegetable and food production, traditionally female intensive, are more protected. Commercial crops use on average more agricultural land than other crops and employ more male than female labour. In Zambia a larger share of the labour force (about 40 per cent) than in Bangladesh (about 3 per cent) in this sector is female, but consists only of uneducated women, often working on their husband's crops as unpaid family labour. Although different mechanisms operate in Bangladesh and Zambia, the main effect of uniform tariffs in both is an overall small decline in market output (with agriculture production increasing and all other activities declining), a slight increase in leisure and almost no change in social reproduction. This is shown in table 17.

Table 17 – Effects of uniform protection on output (percentage changes from the base case)

	Bangladesh	Zambia
Market, of which:	-0.2	-0.3
Agriculture	0.2	0.1
Mining	-	-1.0
Manufacturing	-1.2	-0.1
Services	-0.1	-0.2
Social reproduction	0.0	0.1
Leisure	0.0	0.2

Source: Simulation results.

53 However the effects of changes in these parameter values are rather weak. Sensitivity analysis over a wider range of values will be undertaken as a way of testing the robustness of the results.

In agriculture, as expected, the rise is in male-intensive commercial crops and away from female-intensive crops. Production of the main export – copper in Zambia and ready-made garments in Bangladesh – falls, but more so in Bangladesh (8 per cent compared with 1 per cent in Zambia), where RMG are more dependent than mining in Zambia on imported inputs whose price increases as a result of the tariff (the tariff on other textiles used in garment production is below average in the base case). The resulting impact on the functional distribution of income in both countries is that returns to land rise while returns to all other factors fall. This is paradoxical in Zambia given the difference in land/labour ratios. A simple Heckscher-Ohlin analysis would lead one to expect that an across the board rise in protection would reduce the returns to land in Zambia because it is the abundant factor. The reason is that land in the model is only agricultural land and hence does not include natural resources.

As described in table 18, female wages decline in absolute terms in both Bangladesh and Zambia, with the exception of uneducated female workers in Zambia who gain slightly from expansion of commercial crops. Because of likely gender asymmetries in relations of production, however, it is not clear whether these women would have control over their higher income or whether this would be managed by their male relatives. Because in Bangladesh the economy-wide demand for female labour declines more than the demand for male labour, the gender wage gap widens. Conversely, in Zambia, because the economy-wide demand for male labour declines more than the demand for male labour, the gender wage gap narrows, except for women with primary education who are the most negatively affected by the decline in female-intensive agriculture.

Table 18 – Effects of uniform protection on female market participation and wages (percentage changes from the base case)

	Female no education	Female primary education	Female secondary education	Female high education
Bangladesh				
Market employment	-0.3	-0.6	-0.5	-0.2
Social reproduction	0.0	0.1	0.1	0.0
Leisure	0.1	0.1	0.1	0.0
Wages				
Absolute	-0.2	-0.4	-0.6	-0.8
Relative to males	-0.4	-0.6	-0.6	-0.4
Zambia				
Market employment	0.0	-0.1	-0.5	-0.3
Social reproduction	-0.1	0.1	0.0	0.0
Leisure	0.1	0.2	0.2	0.1
Wages				
Absolute	0.1	-0.4	-0.3	-0.7
Relative to males	0.5	-0.1	0.7	0.2

Source: Simulation results.

2.2.4. Higher import price of food grains

Both Bangladesh and Zambia are net importers of grains. Reform of agricultural policies in OECD countries could cause a rise in the world price of food. An increase by (an arbitrary) 50 per cent of the world price of rice and wheat in Bangladesh and of maize in Zambia was thus simulated to assess the likely gender effects of these reforms. Only 24 per cent of the labour force in grain production in Bangladesh is female, with the majority of it being uneducated. In Zambia maize production employs a larger proportion of women (54 per cent of the total labour force in this sector) and these women mostly have primary education. The rise in the import price of grain causes an increase in its domestic production in both countries, although in Zambia by a larger extent than in Bangladesh (Table 6 shows that Zambia is more import dependent in grain than Bangladesh). Output declines marginally in all other sectors. As shown in table 19, in Zambia social reproduction and leisure fall by the same proportion (0.2 per cent) while in Bangladesh leisure declines by 0.1 per cent and social reproduction is unchanged. These differences in the behaviour of the non-market sectors reflect different wage effects in the two countries, namely small (both absolute and relative) increases in female wages in Zambia and declines in female wages in Bangladesh.

Table 19 – Effects of higher import price of grains on output (percentage changes from the base case)

	Bangladesh	Zambia
Market, of which:	0.0	0.0
Agriculture	0.3	0.7
Mining	-	-0.1
Manufacturing	-0.5	-0.4
Services	-0.1	-0.1
Social reproduction	0.0	-0.2
Leisure	-0.1	-0.2

Source: Simulation results.

Because the sectors that expand use land relatively more intensively than the sectors that contract, in both countries the resulting functional income distribution favours land over other factors of production. Female workers gain in terms of employment and wages in Zambia, while in Bangladesh the gender impact in the market economy appears negative. The results are reported in table 20. The gender wage gap narrows for all women in Zambia. Female wages rise also in absolute terms, for women with no education and with primary education. Their market participation increases by about 0.5 per cent and their time inputs into household work and leisure decline slightly, by a similar proportion. Conversely, in Bangladesh female wages decline for all, both absolutely and relative to men.[54] Uneducated women's market participation increases (by 0.2 per cent) at the expense

[54] A similar simulation with a simplified data set for an earlier period (Fontana and Wood, 2000:1180-1181) lead to conclude that in Bangladesh the impact of higher food import prices on women's absolute and

of their leisure while their participation in social reproduction remains the same. Employment changes for women with higher education – who do not work in agriculture - are slight in both countries but their wages decline, due to lower demand for non-market services, which is more marked in rich households (where the majority of highly educated female workers live).

Table 20 – Effects of higher import price of grains on female market participation and wages (percentage changes from the base case)

	Female no education	Female primary education	Female secondary education	Female high education
Bangladesh				
Market employment	0.2	0.2	0.2	0.2
Social reproduction	0.0	0.0	0.0	0.0
Leisure	-0.1	-0.1	-0.1	-0.1
Wages				
Absolute	-0.2	-0.3	-0.5	-0.7
Relative to males	-0.6	-0.5	-0.5	-0.3
Zambia				
Market employment	0.7	0.5	-0.1	0.0
Social reproduction	-0.4	-0.6	0.1	0.0
Leisure	-0.5	-0.7	0.0	0.0
Wages				
Absolute	0.3	0.6	-0.7	-0.8
Relative to males	0.6	0.3	0.2	0.1

Source: Simulation results.

In both simulation 2.2.3 and simulation 2.2.4 the main change, although in each experiment for different reasons, is an increase in agricultural output and decline in other production, both market and non-market. Within agriculture, it is one particular crop that expands at the expense of other crops – commercial crops, as a result of uniform tariffs, and grains, as a result of possible agricultural reforms in OECD countries. In both cases, and in both countries, this expansion is offset by a fall in female-intensive agricultural production of vegetables and other basic food staples that are less exposed to international trade. The effects on women's well being are ambiguous and vary between uneducated female workers, who are directly affected by these changes, and women with higher education, who do not work in agriculture. Women's wages tend to decline in absolute terms in both countries but increase in relative terms in Zambia. This however is due to downward equalisation of wages rather than upward equalisation, with male wages declining even more than female wages. Increases in uneducated women's participation in agriculture are at the expense of their leisure. Moreover, because of likely inequalities in intra-household

relative wages was positive. This was because of the very aggregate level of the SAM, which had only one agricultural sector and did not distinguish between female-intensive and male-intensive crops.

allocation of power and resources, it is not clear whether these women, mostly working as unpaid family labour on fields managed by male relatives, would have control over higher income earned.

3. COMPARISON OF METHODS

Many different methods can be used to analyse the gender effects of economic reforms: qualitative methods, econometric methods and modelling methods. Each of these methods includes in turn a variety of approaches. For example, some econometric studies use time-series analysis while others are based on panel data analysis. Single-country static general equilibrium models, such as those used in this paper, are only one of many types of models. Modelling can be at the household level, country level or global level, could focus on specific sectors (partial equilibrium) or on the whole economy (general equilibrium) and be either dynamic or static.

Each approach has strengths and weaknesses. No single method or discipline can provide all the answers and often a combination of tools is the best solution. This combination can take various forms. In some cases it might be preferable to use different methods simultaneously but separately, while in others (for example when qualitative information from anthropological and sociological studies is used to specify some model behaviour) a full integration of approaches can be more effective.[55] Validating model results with studies from other methods can also significantly strengthen their influence on policy (Devarajan and Robinson, 2002).

This section compares the model results described in the previous sections with other work in the gender and trade literature. It is divided in three main parts. The first part highlights results that are the same as with other methods. The second part discusses ways in which the modelling approach contributed to a better understanding of the impact (its 'strengths'). The third part examines aspects that the Bangladesh and Zambia models did not cover (their 'limitations'). Some of these limitations are specific to the models used in this paper, while others are characteristic of CGE modelling in general. The third part also suggests how SAMs/CGE models could be improved, so as to reduce their shortcomings relative to what we would like to know about the gender impact of trade.

3.1. Results in common with other methods

The simulation findings that trade liberalisation raises female employment and wages in a labour-abundant country like Bangladesh but is not as beneficial for women in a natural resource-abundant country like Zambia are consistent with other evidence. Several studies –mainly case studies of specific sectors or firms, and some cross-country econometric analyses (reviewed in Joekes and Weston, 1994 and Joekes 1999a) – show that the growth of export-oriented manufacturing, especially in South and South-east Asia, has created

[55] For an interesting discussion on integrating qualitative and quantitative methods in development research see Kanbur (2002) and Kanbur (2001).

many jobs for women, at wages which, though lower than those of men, are higher than they could have earned in the alternative forms of work open to them. Very little research exists on the impact of trade on women in mineral-rich countries like Zambia. The limited research on Sub-Saharan Africa focuses on agriculture. It shows that the impact of expanding exports in this sector is generally less favourable to women and varies according to the prevailing systems of property rights and to other socio-cultural factors governing the gender division of labour (Gladwin, 1992, Joekes, 1999b).

The SAMs and CGE models in this paper expose reasons for the differences in impact. They clearly show where women are located in the economy, and highlight the mechanisms through which changes in the domestic prices of imports and exports affect a country's output structure and hence its factor demand (and wages). Thus in Bangladesh, where the main export is female intensive (and low skill intensive), women benefit from trade liberalisation. Conversely in Zambia, where the main export is a mineral resource that is highly capital and male intensive in production, women are disadvantaged by greater exposure to trade. Moreover, when agricultural output rises because of trade shocks such as uniform protection or higher import prices for grains, women are adversely affected, in both Bangladesh and Zambia, despite being heavily involved in this sector. This outcome, as a glance at the two SAMs reveals, is due to a marked gender division of labour in both countries (although more so in Bangladesh than in Zambia) that assigns women to crops mainly used for household consumption and limits their involvement in commercial crops.

An important point made in feminist economics research (most notably by Elson, 1991) is that increases in female market employment might be at the expense of the time women devote to caring for their families, or, more likely, of their leisure. It often results in heavier work burdens and a decline in well being. Macro-economic analysis that omits explicit consideration of household work and assumes that women's unpaid labour is infinitely elastic points a seriously incomplete picture of the impact of changes in policies on the welfare of women and of their dependents. By incorporating social reproduction and leisure sectors, the model used in this paper addresses these concerns and operationalises them numerically.

The responsiveness of gendered aspects of the division of labour to changes in economic incentives – for example, how much the amount of time women spend on household activities falls in response to improvements in their market wage or employment opportunities– varies depending on a wide range of social and cultural norms. This point is often made in the sociological and anthropological literature. In an analysis of foreign direct investment in Indonesia, Braunstein (2000) discusses how family structures and institutional contexts influence female labour supply. She suggests that women heads of households with few job alternatives available to them may be prepared to work for much lower wages than women in patriarchal households. Changes in institutional arrangements or economic circumstances might also affect women's reservation wages, such as when '... subcontracting in the form of industrial homework is introduced, so even in situations where male heads prefer their wives to stay at home, wives' reservation wages for homework might be very low while those for waged employment outside the home are still high.' (Braunstein, 2000:1164). Although not all of these interesting dimensions and nuances can be represented explicitly in the CGE framework, some can be implicitly captured by the value of key parameters in the model: for instance, the elasticity of substitution between male and female labour in market and non-market production, and the price elasticity of demand for social reproduction. Depending on the values assigned to these key parameters, the magnitudes of the effects of the experiments in this paper have been shown to vary, which is important to consider when designing policies.

3.2. Results not attainable by other methods

The gendered CGE models of Bangladesh and Zambia provide an integrated framework for the analysis of the effects of trade on women which allows consideration of more constraints and interactions than it is possible using other methods.

Most existing research on the gender impact of trade liberalisation looks at specific firms or sectors in isolation, or only at one aspect of welfare (employment or consumption), and hence does not provide sufficient analysis of linkages among different dimensions. Partial equilibrium analysis assumes that repercussions from one market to another will be slight and neglects the indirect effects that change in one sector may have on prices, output and employment in other sectors (both market and non-market). Such approaches cannot produce an accurate measurement of net outcomes – it would not be possible to know whether, for example, the number of female jobs that are destroyed in sectors producing import-substitutes would be greater than the number of female jobs created in female-intensive exporting sectors. Or whether the positive effect on well being from higher wages and market employment would be more than offset by the negative impact on it from reduced leisure.

Moreover, the use of a partial sectoral method to assess the impact of a trade shock in a non-female-intensive sector, would be highly likely to lead to conclude that the shock did not have any gender implications, even though the indirect effects on women were substantial. Most studies of the manufacturing sector in Bangladesh and elsewhere explore effects at the household level (for example Zohir and Paul-Majumdar, 1996), but do not consider linkages with the rest of the market economy. Some of the Africa agricultural studies (for instance Kennedy, 1988 on Kenya, Kumar, 1994 on Zambia and Katz, 1995 on Guatemala) do however go beyond a single-sector approach, since they examine the effects of commercialisation of certain crops on the food production sector, on other non-farm activities, and on consumption as well as income – important steps towards a general equilibrium analysis.

One of the most important advantages of CGE modelling over other existing methods is its ability to include a wide range of macroeconomic, sectoral and social impacts and to provide economy-wide quantification of these effects. It is important to know whether effects of a specific policy measure are big or small and what are the main causal chains. By providing a simulation laboratory for controlled experiments, CGE models improve our understanding of the many ramifications induced by a shock and highlight the strength of various forces at work. This can help to expose particular mechanisms that had not been apparent before.

By contrast with the sectoral studies, more conventional CGE models permit analysis of both direct and indirect effects of trade policies. However, by excluding the household and leisure sectors, they disregard important broader welfare implications and might yield inaccurate results about the impact of such reforms on standard market variables. Within the CGE modelling methods class, gendered models get closer than non-gendered models to results obtained by other methods. Fontana and Wood (2000) provide an example of this in their analysis of an archetype Bangladesh model, by comparing results of the same experiment run with and without the non-market sectors. Exclusion of social reproduction and leisure from the model not only omits important information about women's activities and well being, but also makes the supply of labour to the market economy less flexible. This results in changes in wage rates and employment of men and women that are quantitatively different, although qualitatively similar, from those simulated with the gendered model.

3.3. Model limitations and suggestions for further research

The Bangladesh and Zambia CGE models shed no light on whether gains in female employment from greater trade openness would be sustained over time. Recent studies based on time-series analysis (e.g. Kusago and Tzannatos, 1998, Joekes, 1999) point to a decline in women's share in the manufacturing labour force of several middle-income countries (such as Mexico, Malaysia and South Korea)– a phenomenon often referred to as 'de-feminisation' of employment. Female workers do not seem able to maintain their position within the industrial workforce as the composition of exports moves towards more technologically sophisticated goods. Changes over time in gender patterns of production have been observed also in some African agriculture– these too, often, to women's disadvantage. Evidence (Blackden and Selim, 1993, and Saito, 1994) seems to suggest that, as the prospects for market sales of a crop rises, more men tend to move into its production, e.g. groundnuts in Zambia. On a more positive note, case studies of Bangladesh (Kabeer, 2000, Zohir and Paul-Majumdar, 1996) suggest that increasing female employment has the potential to change families' attitudes towards considering daughters as assets instead of liabilities. This could lead to more girls being sent to school and hence to a better educated female labour force in the future. These long-term changes are likely to affect strategic gender interests in important ways and are better captured by other methods, such as time-series econometrics and qualitative case studies.

Time-series analysis indicates dynamic processes of the gender patterns of work. This brings attention to 'surprises'- or deviations from expected trends some of which could not be anticipated by a model. For a better understanding of the nature of, and reasons for, these 'surprises', qualitative approaches are particularly valuable. Even though qualitative methods might have the disadvantage that their findings cannot be generalised (if random samples are not used), they add depth and nuances to the analysis that could not be captured by any of the quantitative methods. Kabeer (2000), for example, provides a fascinating analysis of the unexpected large rise in female employment in Bangladesh in the 1980s. Through analysis of in-depth interviews of female factory workers and of their family members, her study points to the diversity of social, cultural and economic factors that shape women's behaviour and that of their employers.

The model used in this analysis is a single period static model and assumes labour endowments and production technology to be fixed.[56] In principle, however, CGE models can be made dynamic. For instance, the potential positive long-term effect of trade expansion on female education in Bangladesh could be captured in the model by considering a sequence of equilibria whereby in each period the skill level of the female labour force is updated, and the extent of this change is a function of increases in female-intensive production or a similar such hypothesis. Insights from qualitative research and time-series could significantly contribute to a better design of the model.

The Bangladesh and Zambia models were not able to establish conclusively whether rises in female employment and earnings translate into welfare gains for women. This is because the CGE approach used in this paper does not take into account the nature of production relations and the unequal distribution of power and resources between different people.

An intricate web of institutions and norms mediates individuals' access to resources and its translation into impact, which in-depth qualitative research is better able to explain. Several anthropological and sociological studies (Beneria and Roldan, 1987), for example, suggest that, in general, women are more likely to exercise control over the proceeds of their labour when it is carried out in forms of production which are independent of male household members and in social relationships outside the familial sphere. Kabeer (2000) provides an interesting example of this in her study of the effects of the clothing industry on two different groups of Bangladeshi women, one working in factories in Dhaka and one involved in home-based work in East London. While in Bangladesh the regularity of the wages from the factory jobs, and the location of the work outside the control of male relatives, has increased women's influence on household decisions, and permitted them to escape from situations of oppression, in London the organisation of work around home-based piecework has meant that the empowering effects have been weak. The CGE model, in its current formulation, would record in both cases an increase in female income, without detecting any difference in outcomes arising from differences in women's ability to control resources. This would be a limitation also in the analysis of the agricultural sector, where the organisation of production often differs by crop. A contractual wage labour force whose terms and conditions of employment are akin to those of industrial workers often prevails in non-traditional agriculture (such as cut flowers and beans in Zambia), thus providing women with greater control over their earnings. Conversely, production of more traditional crops is organised in farms owned by male relations where women work as unpaid family labour (Joekes, 1999b).

A more fully developed model of the household based on bargaining behaviour could redress some of these limitations. Game-theoretic approaches – which introduce the idea of preference heterogeneity, bargaining power divergences and individual resource control – are increasingly used to model household decision-making (for example Smith, 1999 and Warner and Campbell, 2000). Collective household models have the advantage that they

[56] Changes in production methods or labour endowments could of course be simulated as part of an experiment.

allow consideration of unequal intra-household resource allocation. However they take the rest of the economy as given and thus neglect feedback effects.

Ideally, if data on consumption and assets were available for each household member, some intra-household allocation aspects could be explored within a CGE framework. This could be done by simply assigning different weights to individual utility functions of women and men. These weights could be chosen so as to reflect differences in asset ownership between spouses (which studies have shown is an important determinant of bargaining power). It might be desirable to take intra-household analysis a step further, by nesting a fully developed household model within a CGE model. This would allow consideration of more interactions between macro and micro dimensions than other approaches, but would have the disadvantage of high computational complexity.

The values of elasticities of substitution between factors of production, income and price elasticities of household consumption, and trade elasticities – parameters that must be set independently of the data in the SAM– are based in the Bangladesh and Zambia models on 'educated guesses'. It would be desirable to estimate model parameters by using econometric approaches. The use of econometric estimates would provide a more accurate description of the behavioural responses of women to labour market changes. Econometrics could also be useful in guiding the choice of other features in the model – suggesting for example what are the most appropriate functional forms for wage equations or demand systems.

A shortcoming of CGE models more in general is to disregard the process required to move from the initial to the final equilibrium state, thus ignoring adjustment costs. For example, women who lose their jobs in import substituting industries might not be able to take advantage of newly created opportunities elsewhere in the economy in the short run, or not at all, if adequate training and assistance is not provided or severe constraints to their physical mobility remain. Some studies of displaced workers (for example Beneria, 1998) provide information by gender on the circumstances of their lay-offs, availability of re-training, length of their unemployment spells, quality of any new employment available to them, and other impacts at the family level. The value of these studies is to highlight important short-term effects neglected by the modelling approach.

Finally, CGE models cannot say anything about women's and men's perceptions and feelings. Subjective happiness is a concept that covers many more aspects of human welfare than the standard concept of utility based on revealed preferences (for a review see Frey and Stutzer, 2002). '…Oddly, while economists generally think that people are the best judges of their own welfare, they resist asking people directly how they feel' (Ravallion, 2001 cited in Kanbur, 2002). Research needs to incorporate the possibility that, in some cases, women might not enjoy their higher income if they face increased social tensions as a result of taking paid work. In other cases, women might derive important psychological benefits from paid work that more than compensate for the loss of leisure time and any social censure. Even as regards taking care of children and the elderly in the household, perceptions across individual women might vary from feeling happy to feeling overburdened. Satyajit Ray, in the 1960s Bengali movie 'Mahanagar' (The big city), beautifully illustrates the complexity facing women in these choices. Addressing these problems require information which is not found in conventional economic analysis but on which there is a growing literature in other disciplines (for example Chen, 1997 and Mohamed and Rajan, 2003).

SAM extensions

The suggestions for model development made in the previous section could only be implemented with better and richer data. There are many ways in which SAMs could be further extended or complemented to permit a richer gender analysis. The ones described here fall mostly under the category of 'internal satellite accounts', i.e. disaggregations of existing SAM accounts. Some suggestions for a few additional 'external satellite accounts' are also made.

Consumption, which is usually reported by household, could be recorded instead for each type of worker or individual household member. This would give an indication of how resources are allocated within the household and hence how policies which affect production or consumption of one particular commodity, or the income of one particular group of workers, would have different implications for the consumption levels of different household members.

A distinction could be made between assets owned by female household members and assets owned by male household members, as well as between any transfer received by them (to document for example whether any child benefit from the government is paid directly to mothers), as these could be useful indicators of bargaining power (Quisumbing and de la Briere, 2000). It would also be helpful to account separately for items of public expenditure (health, education, etc.) and to trace by individual, and not by household, who benefits from government provision of public services.

It could be desirable to account for transportation and other transaction costs by gender. These are often higher for women than for men, for example in most African agricultural sectors (Malmberg Calvo, 1994), which might explain why a high proportion of agricultural production by women remains non-marketed. Some SAMs (for example Zambia (Hausner, 1999) and Mozambique (Arndt et al., 1999)) report already separate accounts for marketing costs by sector.

The social reproduction sector could be broken up into several sub-sectors such as childcare, preparing meals and DIY activities. This would allow a better understanding of gender roles within the household and would help identify which aspects of women's reproductive labour are likely to be most affected when their time inputs to market activities increase. Time allocation studies of developed countries (for example Bonke et al, 2002) show that women usually perform the household tasks which are most energy-intensive and time inflexible, with important implications for their job performance.

Several studies (most notably Floro and Miles, 1999) document that multiple household activities are carried out simultaneously (for example looking after children while cleaning the house). This phenomenon appears to be more frequent among women, who experience greater intensity of work, but not necessarily an increase in working hours, when taking up paid employment. It would not be possible to disentangle the simultaneous undertaking of many activities such as cooking, housekeeping and childcare, but perhaps a way to record an activity in the SAM as producing joint outputs could be found.

Household caring activities have positive social effects and important implications for the well being of the future workforce. It would be helpful to know what is the impact of time re-allocation on dependents when women take up paid market work. Information could be incorporated, for example, on children's labour by gender, to monitor whether girls and boys are kept out of school to undertake household tasks that their employed mothers no longer have time to complete (see for example Katz, 1995). Some indicators could also be constructed to link the provision of care to outcomes – using for instance educational levels of the workforce or health statistics.

Perhaps the SAM format could also be used as the organising principle for describing intra-household allocation of resources, time and power. This could be provided by constructing household level SAMs – as many as the household types in the corresponding economy-wide SAM. In each of the household-SAMs, the household would be treated as if it were a national economy, with various non traded goods produced within the household for home consumption using male, female labour and 'imported' intermediate goods, and exports and imports being the household's cash transactions with the rest of the economy. Household members would be represented in the same way as 'institutions' in the larger SAM, each with separately recorded sources of income, assets, consumption expenditures and transfers to other institutions/household members. Taylor and Adelman (1995) develop a SAM framework for village economies which are described with their own specific institutions and socio-cultural structures. Their study seeks to analyse the functioning of the village economy as well as economic interactions between different villages and between villages and the wider economy. The construction of household SAMs could take the idea of the village SAM one level further down.

CONCLUSION

The CGE model used in this paper provides useful insights into the gendered economic outcomes of trade policies that could not have emerged using other approaches. It is applied comparatively to Bangladesh and Zambia. Simulation results highlight how differences in resource endowments, labour market institutions and socio-cultural norms shape the way in which trade expansion affects gender inequalities, resulting in more favourable effects in Bangladesh than in Zambia.

The paper also suggests that some of the gender effects of trade are better analysed with other methods. In particular, the SAM/CGE approach appears to be more effective in answering questions regarding practical gender needs than in shedding light on how strategic gender needs are affected by economic reforms. No single approach can provide all the insights and information and, hence, the main suggestion of this paper is that a combination of methods be applied.

Methodological tools other than CGE models are useful not only for exploring those dimensions of the gender impact of trade – such as subjective well being or sector-specific changes– that by their very nature require more in depth and more qualitative analyses than what the modelling can offer. Other methods can also be valuable in informing modelling choices. A constant 'dialogue' between methodologies should be encouraged in which insights from one approach are used to enrich, or challenge, findings from another approach. The extent to which different perspectives will be used and how they will be combined will depend, each time, on the particular focus of the analysis and specific country contexts.

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APPENDIX

Table A.1. Mathematical Summary Statement for the CGE Model

SETS

Symbol	Explanation	Symbol	Explanation
$a \in A$	activities	$c \in CMN(\subset C)$	commodities not in CM
$a \in ACES(\subset A)$	activities with a CES function at the top of the technology nest	$c \in CT(\subset C)$	transaction service commodities
$a \in ALEO(\subset A)$	activities with a Leontief function at the top of the technology nest	$c \in CX(\subset C)$	commodities with domestic production
$c \in C$	commodities	$f \in F$	factors
		$f \in FDIS(\subset F)$	disaggregated factors
		$f \in FAGG(\subset F)$	aggregated factors
$c \in CD(\subset C)$	commodities with domestic sales of domestic output	$i \in INS$	institutions (domestic and rest of world)
$c \in CDN(\subset C)$	commodities not in CD	$i \in INSD(\subset INS)$	domestic institutions
$c \in CE(\subset C)$	exported commodities	$i \in INSDNG(\subset INSD)$	domestic non-government institutions
$c \in CEN(\subset C)$	commodities not in CE	$h \in H(\subset INSDNG)$	households
$c \in CM(\subset C)$	imported commodities		

PARAMETERS

Symbol	Explanation	Symbol	Explanation
$cwts_c$	weight of commodity c in the CPI	$\overline{qg}_c$	base-year quantity of government demand
$dwts_c$	weight of commodity c in the producer price index	$\overline{qinv}_c$	base-year quantity of private investment demand
ica_{ca}	quantity of c as intermediate input per unit of activity a	$shif_{if}$	share for domestic institution i in income of factor f
$icd_{cc'}$	quantity of commodity c as trade input per unit of c' produced and sold domestically	$shii_{ii'}$	share of net income of i' to i (i' ∈ INSDNG'; i ∈ INSDNG)
$ice_{cc'}$	quantity of commodity c as trade input per exported unit of c'	ta_a	tax rate for activity a
$icm_{cc'}$	quantity of commodity c as trade input per imported unit of c'	te_c	export tax rate
$inta_a$	quantity of aggregate intermediate input per activity unit	tf_f	direct tax rate for factor f
iva_a	quantity of aggregate intermediate input per activity unit	$\overline{tins}_i$	exogenous direct tax rate for domestic institution i
$\overline{mps}_i$	base savings rate for domestic institution i	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tm_c	import tariff rate
pwe_c	export price (foreign currency)	tq_c	rate of sales tax
pwm_c	import price (foreign currency)	$trnsfr_{if}$	transfer from factor f to institution i
$qdst_c$	quantity of stock change	tva_a	rate of value-added tax for activity a

Table A.1. Mathematical Summary Statement for the CGE Model (continued)

Greek Letters

α_a^a	efficiency parameter in the CES activity function	δ_c^t	CET function share parameter
α_a^{va}	efficiency parameter in the CES value-added function	$\delta_{fagg\,a}^{va}$	CES value-added function share parameter for aggregated factor *fagg* in activity *a*
$\alpha_{fagg\,a}^{va2}$	efficiency parameter in the CES lower level value-added function	$\delta_{fdis\,a}^{va2}$	CES lower level value-added function share parameter for disaggregated factor *f* in activity *a*
α_c^{ac}	shift parameter for domestic commodity aggregation function	γ_{ch}^m	subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	γ_{ach}^h	subsistence consumption of home commodity c from activity a for household h
α_c^t	CET function shift parameter	θ_{ac}	yield of output c per unit of activity a
β_{ach}^h	marginal share of consumption spending on home commodity c from activity a for household h	ρ_a^a	CES production function exponent
β_{ch}^m	marginal share of consumption spending on marketed commodity c for household h	ρ_a^{va}	CES value-added function exponent
δ_a^a	CES activity function share parameter	$\rho_{fdis\,a}^{va2}$	CES lower level value-added function exponent
δ_{ac}^{ac}	share parameter for domestic commodity aggregation function	ρ_c^{ac}	domestic commodity aggregation function exponent
δ_c^q	Armington function share parameter	ρ_c^q	Armington function exponent
		ρ_c^t	CET function exponent

EXOGENOUS VARIABLES

$\overline{CPI}$	consumer price index	$\overline{MPSADJ}$	savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	quantity supplied of factor
$\overline{FSAV}$	foreign savings (FCU)	$\overline{TINSADJ}$	direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	government consumption adjustment factor	$\overline{WFDIST}_{fa}$	wage distortion factor for factor f in activity a
$\overline{IADJ}$	investment adjustment factor		

Table A.1. Mathematical Summary Statement for the CGE Model (continued)

ENDOGENOUS VARIABLES

$DMPS$	change in domestic institution savings rates (= 0 for base; exogenous variable)	QF_{fa}	quantity demanded of factor f from activity a
DPI	producer price index for domestically marketed output	QG_c	government consumption demand for commodity
EG	government expenditures	QH_{ch}	quantity consumed of commodity c by household h
EH_h	consumption spending for household	QHA_{ach}	quantity of household home consumption of commodity c from activity a for household h
EXR	exchange rate (LCU per unit of FCU)	$QINTA_a$	quantity of aggregate intermediate input
$GOVSHR$	government consumption share in nominal absorption	$QINT_{ca}$	quantity of commodity c as intermediate input to activity a
$GSAV$	government savings	$QINV_c$	quantity of investment demand for commodity
$INVSHR$	investment share in nominal absorption	QM_c	quantity of imports of commodity
MPS_i	marginal propensity to save for domestic non-government institution (exogenous variable)	QQ_c	quantity of goods supplied to domestic market (composite supply)
PA_a	activity price (unit gross revenue)	QT_c	quantity of commodity demanded as trade input
PDD_c	demand price for commodity produced and sold domestically	QVA_a	quantity of (aggregate) value-added
PDS_c	supply price for commodity produced and sold domestically	QX_c	aggregated quantity of domestic output of commodity
PE_c	export price (domestic currency)	$QXAC_{ac}$	quantity of output of commodity c from activity a
$PINTA_a$	aggregate intermediate input price for activity a	$TABS$	total nominal absorption
PM_c	import price (domestic currency)	$TINS_i$	direct tax rate for institution i (i ∈ INSDNG)
PQ_c	composite commodity price	$TRII_{ii'}$	transfers from institution i' to i (both in the set INSDNG)
PVA_a	value-added price (factor income per unit of activity)		
PX_c	aggregate producer price for commodity	WF_f	average price of factor
$PXAC_{ac}$	producer price of commodity c for activity a	YF_f	income of factor f
QA_a	quantity (level) of activity	YG	government revenue
QD_c	quantity sold domestically of domestic output	YI_i	income of domestic non-government institution
QE_c	quantity of exports	YIF_{if}	income to domestic institution i from factor f

Table A.1. Mathematical Summary Statement for the CGE Model (continued)

EQUATIONS

#	Equation	Domain	Description
Price Block			
1	$PM_c = pwm_c \cdot (1+tm_c) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c}$ $\begin{bmatrix} \text{import} \\ \text{price} \\ (LCU) \end{bmatrix} = \begin{bmatrix} \text{import} \\ \text{price} \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} \text{tariff} \\ \text{adjust} - \\ \text{ment} \end{bmatrix} \cdot \begin{bmatrix} \text{exchange rate} \\ (LCU\ per \\ FCU) \end{bmatrix} + \begin{bmatrix} \text{cost of trade} \\ \text{inputs per} \\ \text{import unit} \end{bmatrix}$	$c \in CM$	Import Price
2	$PE_c = pwe_c \cdot (1-te_c) \cdot EXR - \sum_{c' \in CT} PQ_{c'} \cdot ice_{c'c}$ $\begin{bmatrix} \text{export} \\ \text{price} \\ (LCU) \end{bmatrix} = \begin{bmatrix} \text{export} \\ \text{price} \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} \text{tariff} \\ \text{adjust} - \\ \text{ment} \end{bmatrix} \cdot \begin{bmatrix} \text{exchange rate} \\ (LCU\ per \\ FCU) \end{bmatrix} - \begin{bmatrix} \text{cost of trade} \\ \text{inputs per} \\ \text{export unit} \end{bmatrix}$	$c \in CE$	***Export Price***
3	$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c}$ $\begin{bmatrix} \text{domestic} \\ \text{demand} \\ \text{price} \end{bmatrix} = \begin{bmatrix} \text{domestic} \\ \text{supply} \\ \text{price} \end{bmatrix} + \begin{bmatrix} \text{cost of trade} \\ \text{inputs per} \\ \text{unit of} \\ \text{domestic sales} \end{bmatrix}$	$c \in CD$	Demand price of domestic non-traded goods
4	$PQ_c \cdot (1-tq_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c$ $\begin{bmatrix} \text{absorption} \\ (\text{at demand} \\ \text{prices net of} \\ \text{sales tax}) \end{bmatrix} = \begin{bmatrix} \text{domestic demand price} \\ \text{times} \\ \text{domestic sales quantity} \end{bmatrix} + \begin{bmatrix} \text{import price} \\ \text{times} \\ \text{import quantity} \end{bmatrix}$	$c \in (CD \cup CM)$	Absorption
5	$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c$ $\begin{bmatrix} \text{producer price} \\ \text{times marketed} \\ \text{output quantity} \end{bmatrix} = \begin{bmatrix} \text{domestic supply price} \\ \text{times} \\ \text{domestic sales quantity} \end{bmatrix} + \begin{bmatrix} \text{export price} \\ \text{times} \\ \text{export quantity} \end{bmatrix}$	$c \in CX$	Marketed Output Value
6	$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$ $\begin{bmatrix} \text{activity} \\ \text{price} \end{bmatrix} = \begin{bmatrix} \text{producer prices} \\ \text{times yields} \end{bmatrix}$	$a \in A$	Activity Price
7	$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$ $\begin{bmatrix} \text{aggregate} \\ \text{intermediate} \\ \text{input price} \end{bmatrix} = \begin{bmatrix} \text{intermediate input cost} \\ \text{per unit of aggregate} \\ \text{intermediate input} \end{bmatrix}$	$a \in A$	Aggregate intermediate input price
8	$PA_a \cdot (1-ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$ $\begin{bmatrix} \text{activity price} \\ (\text{net of taxes}) \\ \text{times activity level} \end{bmatrix} = \begin{bmatrix} \text{value-added} \\ \text{price times} \\ \text{quantity} \end{bmatrix} + \begin{bmatrix} \text{aggregate} \\ \text{intermediate} \\ \text{input price times} \\ \text{quantity} \end{bmatrix}$	$a \in A$	Activity revenue and costs

9	$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c$ $\begin{bmatrix} \text{CPI} \end{bmatrix} = \begin{bmatrix} \text{prices times} \\ \text{weights} \end{bmatrix}$		Consumer price index
10	$DPI = \sum_{c \in C} PDS_c \cdot dwts_c$ $\begin{bmatrix} \text{Producer price index} \\ \text{for non-traded outputs} \end{bmatrix} = \begin{bmatrix} \text{prices times} \\ \text{weights} \end{bmatrix}$		Producer price index for non-traded market output

Production and commodity block

11	$QA_a = \alpha_a^a \cdot \left(\delta_a^a \cdot QVA_a^{-\rho_a^a} + (1-\delta_a^a) \cdot QINTA_a^{-\rho_a^a} \right)^{-\frac{1}{\rho_a^a}}$ $\begin{bmatrix} \text{activity} \\ \text{level} \end{bmatrix} = CES \begin{bmatrix} \text{quantityofaggregatevalueadded ,} \\ \text{quantityaggregateintermediateinput} \end{bmatrix}$	$a \in ACES$	CES technology: activity production function
12	$\frac{QVA_a}{QINTA_a} = \left(\frac{PINTA_a}{PVA_a} \cdot \frac{\delta_a^a}{1-\delta_a^a} \right)^{\frac{1}{1+\rho_a^a}}$ $\begin{bmatrix} \text{value-added –} \\ \text{intermediate-} \\ \text{inputquantity} \\ \text{ratio} \end{bmatrix} = f \begin{bmatrix} \text{intermediate-input} \\ \text{– value-added} \\ \text{priceratio} \end{bmatrix}$	$a \in ACES$	CES technology: Value—Added—Intermediate—Input ratio
13	$QVA_a = ivq_a \cdot QA_a$ $\begin{bmatrix} \text{demand for} \\ \text{value-added} \end{bmatrix} = f \begin{bmatrix} \text{activity} \\ \text{level} \end{bmatrix}$	$a \in ALEO$	Leontief technology: Demand for aggregate value-added
14	$QINTA_a = inta_a \cdot QA_a$ $\begin{bmatrix} \text{demand for aggregate} \\ \text{intermediate input} \end{bmatrix} = f \begin{bmatrix} \text{activity} \\ \text{level} \end{bmatrix}$	$a \in ALEO$	Leontief technology: Demand for aggregate intermediate input
15	$QVA_a = \alpha_a^{va} \cdot \left(\sum_{fagg \in F} \delta_{fagga}^{va} \cdot QF_{fagga}^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$ $\begin{bmatrix} \text{quantityofaggregate} \\ \text{valueadded} \end{bmatrix} = CES \begin{bmatrix} \text{aggregatedfactor} \\ \text{inputs} \end{bmatrix}$	$a \in A$	Value-added and aggregated factor demands
16	$W_{fagg} \cdot \overline{WFDIST}_{fagga} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{fagg \in F'} \delta_{fagga}^{va} \cdot QF_{fagga}^{-\rho_a^{va}} \right) \cdot \delta_{fagga}^{va}$ $\begin{bmatrix} \text{marginalcost of} \\ \text{aggregated factor fagg inactivitya} \end{bmatrix} = \begin{bmatrix} \text{marginalrevenue product} \\ \text{of aggregated factor fagg inactivity a} \end{bmatrix}$	$a \in A$ $f \in F$	Aggregated factor demand
17	$QF_{fagga} = \alpha_{fagga}^{va2} \cdot \left(\sum_{fdis \in F} \delta_{fdisa}^{va2} \cdot QF_{fdisa}^{-\rho_{fagga}^{va2}} \right)^{-\frac{1}{\rho_{fagga}^{va}}}$ $\begin{bmatrix} \text{quantityofaggregate} \\ \text{factor} \end{bmatrix} = CES \begin{bmatrix} \text{disaggregatedfactor} \\ \text{inputs} \end{bmatrix}$	$a \in A$	Lower level factor aggregation

18	$W_{fdis} \cdot \overline{WFDIST}_{fdisa} = W_{fagg} \cdot \overline{WFDIST}_{fagga} \cdot QF_{fagga} \cdot \left(\sum_{f \in F'} \delta^{va2}_{fdisa} \cdot QF_{fdisa}{}^{-\rho^{va2}_{fagga}} \right)^{-1} \cdot \delta^{va2}_{fag}$ $\begin{bmatrix} \text{marginalcost of} \\ \text{disaggregated factor fdis inactivitya} \end{bmatrix} = \begin{bmatrix} \text{marginalrevenue product} \\ \text{offactor finactivitya} \end{bmatrix}$	$a \in A$ $f \in F$	Disaggregated factor demand
19	$QINT_{c\,a} = ica_{c\,a} \cdot QINTA_a$ $\begin{bmatrix} \text{intermediate demand} \\ \text{for commodity c} \\ \text{from activity a} \end{bmatrix} = f \begin{bmatrix} \text{aggregate intermediate} \\ \text{input quantity} \\ \text{for activity a} \end{bmatrix}$	$a \in A$ $c \in C$	Disaggregated intermediate input demand
20	$QXAC_{a\,c} + \sum_{h \in H} QHA_{ach} = \theta_{a\,c} \cdot QA_a$ $\begin{bmatrix} \text{marketed quantity} \\ \text{ofcommodity c} \\ \text{from activity a} \end{bmatrix} + \begin{bmatrix} \text{householdhome} \\ \text{consumption} \\ \text{ofcommodity c} \\ \text{from activity a} \end{bmatrix} = \begin{bmatrix} \text{production} \\ \text{of commodity c} \\ \text{from activity a} \end{bmatrix}$	$a \in A$ $c \in CX$	Commodity production and allocation
21	$QX_c = \alpha^{ac}_c \cdot \left(\sum_{a \in A} \delta^{ac}_{a\,c} \cdot QXAC_{a\,c}{}^{-\rho^{ac}_c} \right)^{-\frac{1}{\rho^{ac}_c - 1}}$ $\begin{bmatrix} \text{aggregate} \\ \text{marketed} \\ \text{production of} \\ \text{commodity c} \end{bmatrix} = CES \begin{bmatrix} \text{activity-specific} \\ \text{marketed} \\ \text{productionof} \\ \text{commodity c} \end{bmatrix}$	$c \in CX$	Output Aggregation Function
22	$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta^{ac}_{a\,c} \cdot QXAC^{-\rho^{ac}_c}_{a\,c} \right)^{-1} \cdot \delta^{ac}_{a\,c} \cdot QXAC^{-\rho^{ac}_c - 1}_{a\,c}$ $\begin{bmatrix} \text{marginal cost of com-} \\ \text{modity c from activity a} \end{bmatrix} = \begin{bmatrix} \text{marginal revenue product of} \\ \text{commodity c from activity a} \end{bmatrix}$	$a \in A$ $c \in CX$	First-Order Condition for Output Aggregation Function
23	$QX_c = \alpha^t_c \cdot \left(\delta^t_c \cdot QE_c^{\rho^t_c} + (1 - \delta^t_c) \cdot QD_c^{\rho^t_c} \right)^{\frac{1}{\rho^t_c}}$ $\begin{bmatrix} \text{aggregate marketed} \\ \text{domestic output} \end{bmatrix} = CET \begin{bmatrix} \text{exportquantity,domestic} \\ \text{salesof domesticoutput} \end{bmatrix}$	$c \in (CE \cap CD)$	Output Transformation (CET) Function
24	$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta^t_c}{\delta^t_c} \right)^{\frac{1}{\rho^t_c - 1}}$ $\begin{bmatrix} \text{export-domestic} \\ \text{supplyratio} \end{bmatrix} = f \begin{bmatrix} \text{export-domestic} \\ \text{priceratio} \end{bmatrix}$	$c \in (CE \cap CD)$	Export-Domestic Supply Ratio
25	$QX_c = QD_c + QE_c$ $\begin{bmatrix} \text{aggregate} \\ \text{marketed} \\ \text{domesticoutput} \end{bmatrix} = \begin{bmatrix} \text{domesticmarket} \\ \text{salesof domestic} \\ \text{output [for} \\ c \in (CD \cap CEN)] \end{bmatrix} + \begin{bmatrix} \text{exports [for} \\ c \in (CE \cap CDN)] \end{bmatrix}$	$c \in$ $(CD \cap CEN)$ $\cup$ $(CE \cup CDN)$	Output Transformation for Non-Exported Commodities

26	$QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + (1-\delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}}$ $\begin{bmatrix} composite \\ supply \end{bmatrix} = f \begin{bmatrix} import quantity, domestic \\ use of domestic output \end{bmatrix}$	$c \in (CM \cap CD)$	Composite Supply (Armington) Function
27	$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1-\delta_c^q} \right)^{\frac{1}{1+\rho_c^q}}$ $\begin{bmatrix} import\text{-}domestic \\ demand\ ratio \end{bmatrix} = f \begin{bmatrix} domestic\text{-}import \\ price ratio \end{bmatrix}$	$c \in (CM \cap CD)$	Import-Domestic Demand Ratio
28	$QQ_c = QD_c + QM_c$ $\begin{bmatrix} composite \\ supply \end{bmatrix} = \begin{bmatrix} domestic use of \\ marketed domestic \\ output\ [for \\ c \in (CD \cap CMN)] \end{bmatrix} + \begin{bmatrix} imports\ [for \\ c \in (CM \cap CDN)] \end{bmatrix}$	$c \in (CD \cap CMN) \cup (CM \cap CDN)$	Composite Supply for Non-Imported Outputs and Non-Produced Imports
29	$QT_c = \sum_{c' \in C'} \left(icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'} \right)$ $\begin{bmatrix} demand for \\ transactions \\ services \end{bmatrix} = \begin{bmatrix} sum\ of\ demands \\ for\ imports,\ exports, \\ and\ domestic\ sales \end{bmatrix}$	$c \in CT$	Demand for Transactions Services

Institution block

28	$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa}$ $\begin{bmatrix} income\ of \\ factor\ f \end{bmatrix} = \begin{bmatrix} sum\ of\ activity\ payments \\ (activity\text{-}specific\ wages \\ times\ employment\ levels) \end{bmatrix}$	$f \in F$	Factor Income
29	$YIF_{if} = shif_{if} \cdot \left[\left(1 - tf_f \right) \cdot YF_f - trnsfr_{rowf} \cdot EXR \right]$ $\begin{bmatrix} income\ of \\ institution\ i \\ from\ factor\ f \end{bmatrix} = \begin{bmatrix} share\ of\ income \\ of\ factor\ f\ to \\ institution\ i \end{bmatrix} \cdot \begin{bmatrix} income\ of\ factor\ f \\ (net\ of\ tax\ and \\ transfer\ to\ RoW) \end{bmatrix}$	$i \in INSD$ $f \in F$	Institutional factor incomes
30	$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{igov} \cdot \overline{CPI} + trnsfr_{irow} \cdot EXR$ $\begin{bmatrix} income\ of \\ institution\ i \end{bmatrix} = \begin{bmatrix} factor \\ income \end{bmatrix} + \begin{bmatrix} transfers \\ from other\ domestic \\ non\text{-}government \\ institutions \end{bmatrix} + \begin{bmatrix} transfers \\ from \\ government \end{bmatrix} + \begin{bmatrix} transfers \\ from \\ RoW \end{bmatrix}$	$i \in INSDNG$	Income of domestic, non-government institutions
31	$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - TINS_{i'}) \cdot YI_{i'}$ $\begin{bmatrix} transfer\ from \\ institution\ i'\ to\ i \end{bmatrix} = \begin{bmatrix} share of\ \ net\ income \\ of\ institution i' \\ transfered to\ i \end{bmatrix} \cdot \begin{bmatrix} income\ of\ institution \\ i',\ net\ of\ savings\ and \\ direct\ taxes \end{bmatrix}$	$i \in INSDNG$ $i' \in INSDNG$	Intra-Institutional Transfers

32	$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih}\right) \cdot (1 - MPS_h) \cdot (1\text{-}TINS_h) \cdot YI_h$ $\begin{bmatrix}\text{household income}\\ \text{disposable for}\\ \text{consumption}\end{bmatrix} = \begin{bmatrix}\text{household income, net of direct}\\ \text{taxes, savings, and transfers to}\\ \text{other non-government institutions}\end{bmatrix}$	$h \in H$	Household Consumption Expenditure
33	$QH_{ch} = \gamma_{ch} + \dfrac{\beta^m_{ch} \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma^m_{c'h} - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma^h_{ac'h} \right)}{PQ_c}$ $\begin{bmatrix}\text{quantity of}\\ \text{household demand}\\ \text{for commodity} c\end{bmatrix} = f \begin{bmatrix}\text{household}\\ \text{consumption}\\ \text{spending,}\\ \text{market price}\end{bmatrix}$	$c \in C$ $h \in H$	Household Consumption Demand for Marketed commodities
34	$QHA_{ach} = \gamma^h_{ach} + \dfrac{\beta^h_{ach} \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma^m_{c'h} - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma^h_{ac'h} \right)}{PXAC_{ac}}$ $\begin{bmatrix}\text{quantity of}\\ \text{household demand}\\ \text{for home commodity} c\\ \text{from activity } a\end{bmatrix} = f \begin{bmatrix}\text{household}\\ \text{disposable}\\ \text{income,}\\ \text{producer price}\end{bmatrix}$	$a \in A$ $c \in C$ $h \in H$	Household Consumption Demand for Home Commodities
35	$QINV_c = \overline{IADJ} \cdot \overline{qinv}_c$ $\begin{bmatrix}\text{fixed investment}\\ \text{demand for}\\ \text{commodity} c\end{bmatrix} = \begin{bmatrix}\text{adjustment factor}\\ \text{times}\\ \text{base-year fixed}\\ \text{investment}\end{bmatrix}$	$c \in CINV$	Investment Demand
36	$QG_c = \overline{GADJ} \cdot \overline{qg}_c$ $\begin{bmatrix}\text{government}\\ \text{consumption}\\ \text{demand for}\\ \text{commodity} c\end{bmatrix} = \begin{bmatrix}\text{adjustment factor}\\ \text{times}\\ \text{base-yeargovernment}\\ \text{consumption}\end{bmatrix}$	$c \in C$	Government Consumption Demand
37	$YG = \sum_{i \in INSDNG} TINS_i \cdot YI_i + \sum_{f \in F} tf_f \cdot YF_f + \sum_{a \in A} tva_a \cdot PVA_a \cdot QVA_a$ $+ \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CM} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in CE} te_c \cdot pwe_c \cdot QE_c \cdot EXR$ $+ \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR$ $\begin{bmatrix}\text{government}\\ \text{revenue}\end{bmatrix} = \begin{bmatrix}\text{direct taxes}\\ \text{from}\\ \text{institutions}\end{bmatrix} + \begin{bmatrix}\text{direct taxes}\\ \text{from}\\ \text{factors}\end{bmatrix} + \begin{bmatrix}\text{value-}\\ \text{added}\\ \text{tax}\end{bmatrix}$ $+ \begin{bmatrix}\text{activity}\\ \text{tax}\end{bmatrix} + \begin{bmatrix}\text{import}\\ \text{tariffs}\end{bmatrix} + \begin{bmatrix}\text{export}\\ \text{taxes}\end{bmatrix}$ $+ \begin{bmatrix}\text{sales}\\ \text{tax}\end{bmatrix} + \begin{bmatrix}\text{factor}\\ \text{income}\end{bmatrix} + \begin{bmatrix}\text{transfers}\\ \text{from}\\ \text{RoW}\end{bmatrix}$		Government Revenue
38	$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI}$ $\begin{bmatrix}\text{government}\\ \text{spending}\end{bmatrix} = \begin{bmatrix}\text{government}\\ \text{consumption}\end{bmatrix} + \begin{bmatrix}\text{transfers to domestic}\\ \text{non-government}\\ \text{institutions}\end{bmatrix}$		Government Expenditures

System Constraint Block

39 $$\sum_{a\in A} QF_{fa} = \overline{QFS}_f \qquad f \in F$$ Factor market

$$\begin{bmatrix} demand\ for \\ factor\ f \end{bmatrix} = \begin{bmatrix} supply of \\ factor f \end{bmatrix}$$

40 $$QQ_c = \sum_{a\in A} QINT_{ca} + \sum_{h\in H} QH_{ch} + QG_c + QINV_c + qdst_c + QT_c \qquad c \in C$$ Composite Commodity Markets

$$\begin{bmatrix} composite \\ supply \end{bmatrix} = \begin{bmatrix} intermediate \\ use \end{bmatrix} + \begin{bmatrix} household \\ consumption \end{bmatrix} + \begin{bmatrix} government \\ consumption \end{bmatrix} + \begin{bmatrix} fixed \\ investment \end{bmatrix} + \begin{bmatrix} stock \\ change \end{bmatrix} + \begin{bmatrix} trade \\ input\ use \end{bmatrix}$$

41 $$\sum_{c\in CM} pwm_c \cdot QM_c + \sum_{f\in F} trnsfr_{rowf} = \sum_{c\in CE} pwe_c \cdot QE_c + \sum_{i\in INSD} trnsfr_{irow} + \overline{FSAV}$$ Current Account Balance for RoW (in Foreign Currency)

$$\begin{bmatrix} import \\ spending \end{bmatrix} + \begin{bmatrix} factor \\ transfers \\ to\ RoW \end{bmatrix} = \begin{bmatrix} export \\ revenue \end{bmatrix} + \begin{bmatrix} institutional \\ transfers \\ from\ RoW \end{bmatrix} + \begin{bmatrix} foreign \\ savings \end{bmatrix}$$

42 $$YG = EG + GSAV$$ *Government Balance*

$$\begin{bmatrix} government \\ revenue \end{bmatrix} = \begin{bmatrix} government \\ expenditures \end{bmatrix} + \begin{bmatrix} government \\ savings \end{bmatrix}$$

43 $$TINS_i = \overline{tins}_i \cdot \left(1 + \overline{TINSADJ} \cdot tins01_i\right) + \overline{DTINS} \cdot tins01_i \qquad i \in INSDNG$$ Direct institutional tax rates

$$\begin{bmatrix} direct\ tax \\ rate\ for \\ institution\ i \end{bmatrix} = \begin{bmatrix} base\ rate\ adjusted \\ for\ scaling\ for \\ selected\ institutions \end{bmatrix} + \begin{bmatrix} point\ change \\ for\ selected \\ institutions \end{bmatrix}$$

44 $$MPS_i = \overline{mps}_i \cdot \left(1 + \overline{MPSADJ} \cdot mps01_i\right) + DMPS \cdot mps01_i \qquad i \in INSDNG$$ Institutional savings rates

$$\begin{bmatrix} savings \\ rate\ for \\ institution\ i \end{bmatrix} = \begin{bmatrix} base\ rate\ adjusted \\ for\ scaling\ for \\ selected\ institutions \end{bmatrix} + \begin{bmatrix} point\ change \\ for\ selected \\ institutions \end{bmatrix}$$

45 $$\sum_{i\in INSDNG} MPS_i \cdot \left(1 - TINS_i\right) \cdot YI_i + GSAV + EXR \cdot \overline{FSAV} = \sum_{c\in C} PQ_c \cdot QINV_c + \sum_{c\in C} PQ_c \cdot qdst_c$$ Savings-Investment Balance

$$\begin{bmatrix} non\text{-}govern\text{-} \\ ment\ savings \end{bmatrix} + \begin{bmatrix} government \\ savings \end{bmatrix} + \begin{bmatrix} foreign \\ savings \end{bmatrix} = \begin{bmatrix} fixed \\ investment \end{bmatrix} + \begin{bmatrix} stock \\ change \end{bmatrix}$$

46 $$TABS = \sum_{h\in H}\sum_{c\in C} PQ_c \cdot QH_{ch} + \sum_{a\in A}\sum_{c\in C}\sum_{h\in H} PXAC_{ac} \cdot QHA_{ach} + \sum_{c\in C} PQ_c \cdot QG_c + \sum_{c\in C} PQ_c \cdot QINV_c + \sum_{c\in C} PQ_c \cdot qdst_c$$ Total Absorption

$$\begin{bmatrix} total \\ absorption \end{bmatrix} = \begin{bmatrix} household \\ market \\ consumption \end{bmatrix} + \begin{bmatrix} household \\ home \\ consumption \end{bmatrix} + \begin{bmatrix} government \\ consumption \end{bmatrix} + \begin{bmatrix} fixed \\ investment \end{bmatrix} + \begin{bmatrix} stock \\ change \end{bmatrix}$$

47	$$INVSHR \cdot TABS = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$$ $$\begin{bmatrix} \textit{investment-} \\ \textit{absorption} \\ \textit{ratio} \end{bmatrix} \cdot \begin{bmatrix} \textit{total} \\ \textit{absorption} \end{bmatrix} = \begin{bmatrix} \textit{fixed} \\ \textit{investment} \end{bmatrix} + \begin{bmatrix} \textit{stock} \\ \textit{change} \end{bmatrix}$$	Ratio of Investment to Absorption
48	$$GOVSHR \cdot TABS = \sum_{c \in C} PQ_c \cdot QG_c$$ $$\begin{bmatrix} \textit{government} \\ \textit{consumption-} \\ \textit{absorption} \\ \textit{ratio} \end{bmatrix} \cdot \begin{bmatrix} \textit{total} \\ \textit{absorption} \end{bmatrix} = \begin{bmatrix} \textit{government} \\ \textit{consumption} \end{bmatrix}$$	Ratio of Government Consumption to Absorption

ROUND TABLE DISCUSSIONS : CONCLUSIONS FOR POLICY MAKERS

COMMUNICATION FROM JEAN-BAPTISTE GROS[57]

I am working on the impact of globalization on labour markets, poverty and distributional issues in developing countries for the ILO. Consequently, I do not feel appropriate for me to comment on the environmental part of the issue at stake. Although I learned a great deal during this two-day seminar, I am sure other participants in this round table would approach the issue in a more authorized manner. My preferences would be to deal with the social aspects of trade liberalization in developing countries.

In the course of the two days, I learned a lot about sustainability impact assessments (SIA) too and I would like to thank the E.C. contributors and Mr. Kirkpatrick for their clear presentation of what could be called their methodology to establish a methodology. I would welcome another invitation in the future to a presentation of an already achieved SI assessment in order to make more precise comments and suggestions.

While I was organizing my comments, my main concern was to take into account the third countries' point of view. Implementing SIA responds to the need for the EC to consider the negative side-effects of trade liberalization denounced by the opponents to globalization. However, it could also be interpreted as a way to introduce more conditionality in trade agreements.

The first point is related to the framework of the SI assessments. I would like to know how exactly you manage to disentangle the effect of trade liberalization from the effect of other phenomena, like the increasing spread of skill-biased technology, the growing instability of financial markets or the increasing amount of FDI among others. It is a rather old debate in the economic community but I think that it is still relevant especially if we adopt a policy-oriented focus. In an ex-ante modeling, I understand how you could introduce these effects separately but I don't know how you take into account the fact that all these phenomena are related. For instance, to open up an economy is a factor of technological upgrading and a strong incentive for foreign investors. This is my first point: are we at the moment able to isolate trade effects from the other globalization phenomena? Even if it was possible, is it desirable? If SIA is to be considered as a powerful instrument to reestablish dialog with organizations that criticize the negative impact of trade policy, it is really important to include the trade liberalization policies in a broader framework. The problematic is similar when SIA serves as an element for trade negotiation. How could we expect third countries to agree to speak only on trade effects and ignore the other phenomena while they are totally aware of the relationships that exist between them? They learned in the early nineties that predictions only based on trade effects stand a good chance of being wrong. Moreover, adopting a broader framework will permit the more efficient establishment of what could be the mitigation measures to be implemented or proponed to third countries.

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The second point I would like to raise is related to the output of the SI assessment. It is also an opportunity to stress the progress made on the long way to reconcile supporters and opponents to trade liberalization. Let's recall the three sources of discrepancies identified by Kanbur (2001). First, opponents to trade liberalization insist on the fact that there are losers on the trade liberalization process: it could be the rural sector, women etc. During the seminar, everybody agreed with that: it is of special interest to take into consideration these groups when you design the output index of SIA. Second, markets are not perfect. The new models are making efforts to take into account this phenomenon and I think it is a good direction. The last source of discrepancy is the term we refer to: is it short term or long term? During the workshop Prof. Francois and others referred to problems of adjustment sequences and this is undoubtedly great progress in the long way towards understanding the effects of globalization. But even in the long run, there is no total agreement on the fact that trade opening is good for all people. One of the major problems is related to the precariousness of work. For instance, we have to look beyond simple figures of the number of poor in a given time and take into account the increasing probability of people to be poor at one time. What is at stake is the increasing share of people that stand near the poverty line. You could have the same number of poor people but an increasing number of people that will be poor in one moment of their life. This raises implications on the way to model the trade impact, maybe taking into account the higher own-wage elasticity of labour, but also on the way to design and finance pro-poor programs or social security nets that could be some of the mitigation measure to propone.

This brings us to the third comment I would like to make. It refers to the establishment of mitigation measures. One of the dimensions of the impact of trade liberalization is the capability of states to address the negative side-effects of this policy. Actually their increasing weakness could be seen in part as a result of trade liberalization. How could we expect that they adopt social and environmental policies if they are reducing their income, cutting tariffs and competing by lowering taxes on capital and high income households? Moreover an increasing part of the economy is becoming informal as has been well documented in Latin America and is now beyond the state's reach. The increased efficiency in the tradable goods sector has led a lot of people to establish themselves in the informal sector. All these issues have to be taken into account in the SI assessments and I think it is something that should be further explored. To conclude, it is obviously very good to implement mitigation measures but I wonder: who is going to pay for them and how can they be implemented in an efficient way?

COMMUNICATION FROM ROBERT R. TEH JR.[58]

Since the mid-1990s, a growing number of frameworks or methodologies have been developed for undertaking environmental assessments of trade agreements. They have been developed by national governments, non-governmental organisations, regional institutions and international organisations. Assessments have been performed on, among others, the Uruguay Round Agreements, the North American Free Trade Agreement and a number of bilateral free trade arrangements involving the US. Canada, the United States and the European Communities have required environmental assessments of certain trade agreements. The methodologies are now to be used to review possible scenarios and outcomes of the current WTO negotiations.

What explains this demand for environmental or sustainability impact assessment of trade agreements? One is the increased importance assigned by the international community to environmental or sustainable development issues, which had been building up since the Stockholm Conference on the Human Environment in 1972. A second is the success of trade liberalization initiatives in the 1990s. We not only had the conclusion of the UR negotiations and the establishment of the WTO; we also had the successful conclusion of NAFTA and the establishment of the single European market. There was also an explosion of regional trading arrangements during the last decade.

Additionally, the nature of the agreements concluded during the Uruguay Round of negotiations raised fears. They were no longer just about border measures but required conformity of domestic measures to international agreements. The establishment of a binding dispute settlement mechanism in the WTO had the potential of circumscribing the autonomy of national authorities to take actions in non-trade areas, if these actions had negative trade impacts on another WTO member. In this context, the resolution of a number of environment-related cases, e.g. the United States-Tuna, United States-Gasoline and United States-Shrimp, in the WTO dispute settlement mechanism became a catalyst in the environmental community for wanting to examine trade agreements to see whether they limit individual country's rights to take trade measures to achieve environmental objectives. In all three cases, WTO panels or appellate bodies decided against the trade measures taken by the US for environmental objectives.

Given this background, there is a charitable and an uncharitable view about why these assessments are being undertaken. The charitable view is that national authorities are honestly trying to ensure coherence in their trade and environment stance in international negotiations and improving governance. The uncharitable view is that these assessments are intended merely to placate civil society groups or to provide additional leverage in current WTO negotiations. The reality is probably a mixture of all of these motivations.

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What is salutary about the Commission's approach is that it has contracted out the assessment to an academic or research institution. So there is, at least in theory, arms-length distance between the users of the research and the institutions producing the analysis. It is essential for the legitimacy of the SIA process to maintain this arms-length relationship. While an arms length relationship is necessary for the credibility of the SIA process, it is not sufficient. The other important ingredients are a theoretically sound conceptual framework, the application of a set of rigorous tools in the assessment and the collection of good data.

The theory of comparative advantage is one of the oldest and most hallowed insights of economic science. We have several long-standing trade models, which usually serve as natural points of departure for economic analysis, for example, the Ricardian and the Heckscher-Ohlin (factor-proportions) models of trade. In recent decades, there has been a growth in interest and support for models which incorporate imperfect competition, increasing returns and product differentiation.[59]

In contrast, we have no standard model of trade and environment[60] with the same degree of acceptance in the profession. Instead, we have a number of postulated links between trade and environment with some often divergent views and empirical results regarding how important those links are. Some of the postulated relations between trade and environment include the U-shaped environmental Kuznets curve; the scale, composition and technique effects. We also have several important hypothesis related to investments - the pollution haven thesis, race to the bottom and regulatory chill impacts. Many of these hypotheses are difficult to embed in a single theoretical framework thereby allowing an integrated assessment of the various postulated linkages. The empirical results varies widely and conclusive answers are often difficult to draw. In the case of the environmental Kuznets curve for example, the shape and strength of the relationship seems to vary with the environmental media (with the effect being stronger for air pollution); much of the evidence also comes from cross-section data rather than from time-series data (Grossman and Krueger, 1995; Stern, 1998; Dasgupta, et al, 2002).

As far as the SIA methodology is concerned, I had already given my view that as it currently stands, the methodology is really an assessment of the economic, social and environmental impact of trade negotiations rather than a sustainable impact assessment of trade negotiations. I also highlighted the need for a cost benefit framework to inform policymakers' decision-making process.

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59 This literature includes Krugman (1979), Lancaster (1980), Dixit and Norman (1980), Helpman (1981) and Helpman and Krugman (1985).

60 However, this does not mean that effort has been lacking in trying to develop such models. See for example, Copeland and Taylor (1994, 1995, 2001). Their most recent paper is of a general equilibrium pollution and trade model where they are able to derive the standard factor proportion explanation; pollution-haven hypothesis; and scale, composition and technique effects from their model.

Second, while the assessment frameworks have argued about the need to employ a wide range of assessment tools – scoring, case studies, causal chain analysis, legal analysis, econometric models, partial equilibrium models, applied general equilibrium models - there seems to be an over reliance on qualitative analysis. Consequently, most of the applications or studies have been unable to yield rigorous or precise conclusions about the environmental or social impacts of the trade agreements.

My own inclination as an economist is to favour the more widespread use of modelling in these assessments. But most of the widely known CGE models (GREEN, TEQUILA, GTAP-E) incorporating economy-environment interactions are concerned about energy use and the resulting transboundary environmental effects. But it seems to me that the requirements for the environmental assessment frameworks is for modelling at the regional or local level because environmental impacts are frequently local in nature. Professor Flichman's paper yesterday raised this point in the context of adequately modelling bio-physical processes. The natural unit of analysis for these processes, he says, is at the farm or regional level, where the region is defined by its agronomic or climatic characteristics. CGE models use the nation as the unit of analysis because trade policy is made at the national and not at the local level. I submit that his insight not only applies to agriculture and natural resources but in some cases to manufacturing as well. We know that some industrial sectors tend to cluster in certain geographical areas because of agglomeration or network effects. Just think of Silicon Valley or Detroit. During the negotiations on NAFTA, a lot of the environmental concern was focused on the US-Mexican border, which had experienced large growth in industrial activity even before NAFTA, but where infrastructure facilities for water supply, sewage treatment, and hazardous and solid waste disposal had proved to be inadequate, particularly on the Mexican part of the divide. But most CGE models have SAMS that use data which are averaged at the national level so simulations would fail to capture these local environmental pressures. So you could have a simulation that shows pollution emissions rising by a minuscule amount at the national level and the analyst may be tempted to conclude that there is therefore no environmental risk. But the emissions or pollution may all be concentrated in a single watershed, a forest, or a city. This seems to be where the gap is insofar as quantitative tools are concerned.

The last point, but certainly not the least, is related to the availability and quality of indicators of environmental and social sustainability. Although various countries collect environmental statistics, these tend to be interdisciplinary; their sources are dispersed, there is an absence of time-series data and a variety of methods are applied in their compilation. A survey undertaken by the UN Statistical Division suggested that countries differed widely in how they developed and organised environmental statistics.

So where does this leave us? We need to make substantial progress in all these areas - collection of good environmental data, development and use of relevant quantitative tools or models, and better theory -if the assessments are to be convincing not only to the proponents and users, but also to trade partners, the academic and research community and civil society.

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