The World Tourism Organization (UNWTO), a United Nations specialized agency, is the leading international organization with the decisive and central role in promoting the development of responsible, sustainable and universally accessible tourism. It serves as a global forum for tourism policy issues and a practical source of tourism know-how. Its membership includes 156 countries, 6 territories, 2 permanent observers and over 400 Affiliate Members.
COMPUTABLE GENERAL EQUILIBRIUM MODELLING FOR TOURISM POLICY:
INPUTS AND OUTPUTS

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Abstract

In recent years economic impact analysis in tourism has undergone a profound change in approach. In contrast to earlier emphasis on destination input-output models to provide multiplier values to determine the effects (positive and negative) of tourism demand shocks on economic variables such as gross domestic product, value added and employment, computable general equilibrium (CGE) models, are being used worldwide to estimate the resulting net macroeconomic and industry effects and for tourism policy analysis. This report identifies several features of the economy that determine the size of the economic impacts from any given shock to tourism demand that make CGE model a particularly suitable technique for economic impact analysis. It outlines the structure of a typical CGE model, identifies common features of models in use internationally, and addresses some aspects of operationalising these models. The report also discusses applications of CGE modelling to tourism, identifying several areas where tourism analysis and policy have been suitably informed as a result of such modelling. Particular insights that CGE modelling can bring to tourism planning, forecasting and policy analysis are identified. Concerns that have been raised about CGE modelling are discussed. The report concludes with a discussion of the skills requirements for CGE modelling and training courses offered globally and online by both private and public education providers. In a context of ongoing theoretical and practical development, CGE tourism modelling provides a versatile and effective means of examining the wide range of scenarios that can occur in both developed and developing destinations.

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1. Introduction

1.1. In tourism research and policy analysis, economic impact analysis is typically employed to trace the flows of spending associated with tourism activity in an economy through business, households and government to identify, both ex post and ex ante, the resulting changes in economic variables such as sales, output, household income, value added, government tax revenues and employment. Economic impact refers to the changes in the economic contribution resulting from specific events or activities that comprise ‘shocks’ to the tourism system. This is distinct from the contribution itself. Economic impact analysis estimates the changes that take place in an economy due to an existing or proposed project, action, event or policy shock. Examples of such “shocks” include growth or contraction in tourism flows, changes in policy settings, such as through amendments to taxes or visa requirements, changes in destination marketing activity, the holding of a mega-event, or provision of new tourism related infrastructure.

1.2. Various economic impact techniques have been employed by researchers in different contexts. A major objective is to inform policy makers as to the implications of tourism shocks on appropriate allocation of resources both within the tourism sector itself and between tourism and other sectors of the economy. The accuracy of any technique depends on its capacity to acknowledge economic realities both in their structural assumptions and in the attributes of the destination context of the modelling.

1.3. Including the introduction, this report comprises ten sections. The following section identifies several features of the economy that determine the size of the economic impacts (positive or negative) from any given shock to tourism demand. The most sophisticated type of model, capable of addressing the economic realities that influence economic impacts of changes in tourism expenditure, is a computable general equilibrium (CGE) model. Section 3 outlines the growing use of CGE modelling worldwide. Section 4 outlines the structure of a typical CGE model, identifying common features of models in use internationally. Section 5 discusses some aspects of operationalising CGE models. Section 6 discusses applications of CGE modelling to tourism, identifying several areas where tourism analysis and policy have been suitably informed as a result of such modelling. Section 7 identifies particular insights that CGE modelling can bring to tourism planning, forecasting and policy analysis. Section 8 addresses some concerns that have been raised about CGE modelling. While some have substance, others reflect longstanding confusions regarding the technique. Section 9 addresses skills requirements for CGE modelling and training courses offered globally and online by both private and public education providers. Section 10 concludes the report.

2. What Determines the Economic Impact of a Tourism Expenditure Shock?

2.1. Obviously, the size of the shock (positive or negative) is important. For any given expenditure shock to a destination, the change in economic variables will vary according to several features of the economy (Dwyer et al, 2000). These include:

- The particular industries that are the recipients of the direct expenditure;
- Strengths of the business linkages between the different industry sectors in the economy;
- The assumed factor constraints (supplies of land, labour, capital);
- The import content of consumer goods and inputs to production;
- The production and consumption relationships assumed;
- Changes in the prices of inputs and outputs;
- Changes in the exchange rate;
- The workings of the labour market;
- The government fiscal policy stance.

2.2. In earlier years, tourism researchers and policy makers have employed input-output (I-O) or Social Accounting Matrix (SAM) models to estimate the economic impacts of changes in tourism expenditure. Unfortunately, these models have very restrictive assumptions which affect the accuracy of their estimates (Briassoulis 1991; Dwyer, Forsyth and Spurr 2004). These include:

- All inputs and resources are supplied freely and no resource constraints exist. In real-world economies, however, resource constraints generally are present and must be taken into account when estimating impacts of increased visitor expenditure on economic activity. I-O modelling, which produces positive impacts whatever the context, does not recognize that an expanding tourism industry tends to “crowd out” other sectors of economic activity;

- A constant returns to scale production function is assumed with no substitution among the different inputs. The constant technical coefficients assume away diminishing marginal returns to inputs in production activities and changes in input mix due to price-induced substitution between factors. It is also assumed that there are fixed budget shares in household consumption. If households shift their demand patterns when their income rises, this assumption will be violated;

- Input and output prices are assumed to be fixed. In reality there are likely to be capacity constraints in the economy which cause prices and costs to rise in an expansion of economic activity. Wage and other input price rises will limit the extent of the expansion; and may even lead to contractions in economic activity in some sectors;

- Exchange rate changes are ignored. I-O modelling does not allow for effects through the trade sector, for example, through foreign tourism demand pushing up exchange rates, thereby reducing the competitiveness of traditional exports and import competing firms, with adverse effects on income and employment in those sectors;

- In I-O models, the behaviour of the government budget sector is ignored. In reality tax revenue will increase in an economic expansion, enabling the government to increase spending, reduce other taxes, or some combination. I-O modelling does not allow for the impacts of different constraints on the Public Sector Borrowing Requirement (PSBR) which affects levels of taxation and government spending and, hence, the ultimate economic impacts of the increased tourism expenditure;

- In standard I-O modelling, ‘impacts’ on economic activity, are measured by changes in GDP, employment or similar measures. However, since ‘economic impacts’ do not equate to ‘net benefits’, except under the most restrictive assumptions (Dwyer and Forsyth, 2009), impact estimates represent poor measures of welfare and inappropriate policy objectives.

2.3. In general, I-O or SAM multiplier analysis is more reasonable in economies with high unemployment and small capital constraints than in economies at full employment or where technological limitations on production are more severe. For many real world tourism economies, however, these restrictive assumptions imply that the I-O model or SAM exaggerate the economic impacts of tourism shocks to destinations. Some supply side assumptions can be relaxed in SAM multiplier models by replacing average with marginal budget shares (Pyatt and Round, 1985), and constrained SAM multipliers can be obtained by incorporating inelastic supply
responses for some sectors (Lewis and Thorbecke, 1992) or beyond particular output levels (Parikh and Thorbecke, 1996). Notwithstanding, fixed-price SAMs share the limitations of I-O models with respect to linearity and elastic supplies.

3. The rise of CGE Modelling

3.1. Real world features of demand and supply that affect the economic impacts of shocks to tourism expenditure can only properly be taken into account using Computable General Equilibrium models. The term **computable** describes the capability of this type of model, based on underlying economic benchmark data / representation of an economy, to quantify the effects of a shock to an economy. The term **general** means that it embraces multiple economic agents interacting simultaneously. **Equilibrium** in a CGE occurs at that set of prices at which all producers, consumers, workers and investors are satisfied with the quantities of goods they produce and consume, the number of hours they work, the amount of capital they save and invest etc. (Burfisher, 2011).

3.2. CGE models have their historical origins in input-output methodology, but were developed to overcome the shortcomings of I-O models. Based on neoclassical economic theory, CGE models capture a wider set of economic impacts derived from a shock or the implementation of a specific policy reform. They allow for the inclusion of the constraints absent from I-O calculations and allow flexible prices and wages. They include more general specifications of the behaviour of consumers, producers, governments and investors than other types of models. Substitution possibilities are incorporated so that the behaviour of agents in the model economy is sensitive to changes in relative prices as well as to quantity variables. Importantly, CGE models can incorporate welfare measures - measures of the value of the gain in economic activity less the cost needed to enable this extra activity- giving the simulations policy significance (Dixon and Rimmer, 2002; Blake, 2010). CGE models treat an economy as a whole, allowing for feedback effects of one sector on another. By setting up the economic conditions whereby each market, sector and household reacts to changes in the economy, a CGE approach can model a variety of possible scenarios to fit different real world circumstances. In a CGE model, the initial stimulus can originate anywhere in the economy, and can be literally anything that can occur in an economic framework (Wing, 2004).

3.3. CGE models, now a standard tool of policy analysis for most sectors of the economy, are used extensively by international organisations such as the World Bank, the World Trade Organisation, the IMF, the OECD and the European Commission, as well as by government agencies, research centres and consulting firms worldwide. CGE models can be developed for policy analysis at different spatial levels including single country, single region, multiregional, and multinational (Burfisher, 2011; Cardenete, Guerra and Sancho, 2012). They are widely used to analyse the aggregate welfare and distributional impacts of policies whose effects may be transmitted through multiple markets, or contain mixtures of different taxes, subsidies, quotas or transfer instruments. CGE analysis is a standard tool for the quantitative analysis of policy interference in domains as diverse as hazardous waste management, trade liberalisation, tariff protection, environment–economy interactions, structural adjustment, carbon taxes, emissions trading schemes, effects of climate change, agricultural stabilisation programmes, technological change, labour market deregulation, financial market deregulation, fiscal reform, development planning, macroeconomic reform, economic transition, international capital linkages, environmental regulation, public infrastructure and industry sector studies (Gunning and Keyzer 1995; Dixon and Parmenter 1996; Harrison et al. 2000; Devarajan and Robinson, 2002; de Miguel, et al, 2010).
3.4. The application of CGE modelling to analysis of tourism related issues will generally require access to an existing CGE model designed to apply to the country or region to be studied. In some cases this may mean a CGE model which has been specifically developed for tourism applications, for example, through drawing on Tourism Satellite Account (TSA) definitions and data sources in order to incorporate into the model more extensive information on particular segments of tourism and their interactions with other industries across the economy. Such tourism specific models have already been developed in a number of destinations including the UK (Blake, 2005), Australia (Dwyer, Forsyth, Spurr and Van Ho, 2003; Pham, Jago, Spurr and Marshall, 2015), Spain (Polo and Valle, 2008), Hawaii (Pratt, 2012), and Singapore (Meng, 2014). In many cases, however, it will be sufficient to utilize a more general purpose CGE model which is already in use for the relevant economic region. Most tourism modelling applications will require additional tailoring of the model to reflect the tourism related sectors more specifically. The extent of such tailoring will depend on the level of detail and precision required. For example, a broad study of the gross impact on an economy from a given change in tourism consumption may require less model development. In contrast, a study which seeks to estimate changes by sector of the overall economy as a result of a specific change in one component of tourism expenditure, consequent upon a hotel room tax or the impact of construction of new hotel accommodation in a region, is likely to require the input of more detailed tourism data into the model.

3.5. These considerations will become clearer as we examine the design and structure of a CGE model.

4. Structure of a CGE Model

4.1. The conceptual starting point for Walrasian equilibrium theory that underlies a CGE model is the circular flow of commodities in a closed economy, shown in Figure 1. Figure 1 represents the economy as a system of flows of goods and services between five sectors – producers (firms), households, government, financial markets and rest of world (RoW). Flows of money and goods and services operate through product, factor and capital markets (Wing, 2004).

Figure 1: The Circular Flow of Income in a four sector open economy

4.2. The main actors in the circular flow are households, firms, government and the international sector. Households own the factors of production and are the final consumers of produced commodities. Producers (firms) rent the factors of production from the households for the purpose of producing goods and services that the households then consume. The household receives after-tax factor income, and is the largest source of final demand expenditure. In addition to net factor incomes, households receive a net income from the rest of the world that comprises net transfers from abroad as well as net labor earnings from abroad. The household also receives transfers of income from producers and the government. It spends income received on consumption goods and investment goods (domestic savings). Household demand for each commodity is divided into demand for domestic and imported goods, in a similar manner to the intermediate purchases of industries (Hanson et al, 2002).

4.3. Government collects revenues through personal and corporate taxes and other fees (eg. indirect taxes), and disburses these revenues to firms by way of purchases and households as subsidies and lump-sum transfers, subject to a Public Sector Borrowing Requirement (PSBR).

4.4. The rest of the world supplies goods to domestic markets (imports) and consumes domestic output (exports). Capital markets enable income receipts from the rest of the world through foreign savings and transfers, which include payments for factor services owned abroad and for domestic factor payments that are transferred abroad.

4.5. Through capital markets financial institutions are linked to the government sector and the foreign sector. These flows can go in either direction. If the government runs a deficit, it does so by borrowing from the financial markets. There is a flow from the financial sector to the government sector. If the government runs a surplus, the flow would go in the other direction: government would provide an additional source of saving.

4.6. In tracing the circular flow one can start with the supply of factor inputs (e.g. labour and capital services) to the firms and continue to the supply of goods and services from the firms to the households, who in turn control the supply of factor services. One may also begin with payments, which households receive for the services of labor and capital provided to firms by their primary factor endowment, and which are then used as income to pay producing sectors for the goods and services that the households consume.

4.7. A complete CGE model is a set of equations that describes the circular flow illustrated in Figure 1. A CGE model consists of: equations describing model variables and a database (usually very detailed) consistent with the model equations. The equations describe the economic transactions of households, firms, government, the rest of the world, and capital accounts in the markets for factors of production, commodities, exports and imports, and investment funds (Hanson et al, 2002).

4.8. While Figure 1 does not capture all of the links between sectors and markets that are found in real world economies, it provides a display of some core actors and activities that are of interest to CGE modellers. While Figure 1 shares many of the features of an input-output table or a social accounting matrix (SAM) each market and sector has its own set of economic rules, based on familiar microeconomic theory, that determine how it reacts to external changes. By setting up the economic conditions whereby each market, sector and household reacts to changes in the economy, a CGE model can then model a variety of possible scenarios.
5. Operationalising a CGE Model

5.1. To operationalize a CGE model requires building the associated social accounting matrix (SAM) and obtaining estimates of important behavioural parameters governing consumer demands, production technology, and the substitutability between imports and domestic products. The final step involves calibrating the model.

5.1. Social accounting matrix

5.2. The central core of a CGE model is a set of input-output accounts (tables) or a social accounting matrix (SAM), based on a System of National Accounts. I-O tables are a set of accounts relating the components of final demands to the various industrial sectors, the interaction between industrial sectors, and the relationship between the industrial sectors and the primary inputs. The national accounts can be presented in matrix form at various levels of detail. At the highest level of aggregation, there is an aggregate national accounts matrix (NAM) that distinguishes between the different kinds of accounts. This is represented in abbreviated form in Table 5.1. Each account is represented by a row and column pair. The convention is that incomings or resources are shown in the rows, and outgoings or uses are shown in the columns. Each entry in an aggregate matrix can be considered as the grand total of a detailed sub-matrix, which shows the different categories of transactors involved.

Table 5.1. A simplified national accounts matrix

<table>
<thead>
<tr>
<th>Goods and services</th>
<th>Production (industries)</th>
<th>Generation of income (primary inputs/production factors)</th>
<th>Distribution of income (institutional sectors)</th>
<th>Use of income (institutional sectors)</th>
<th>Capital (institutional sectors)</th>
<th>Rest of the world (RoW), current and capital transactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade &amp; transport margins</td>
<td>Intermediate consumption</td>
<td>GENERATED INCOME, NET</td>
<td>FINAL CONSUMPTION EXPENDITURE</td>
<td>GROSS CAPITAL FORMATION</td>
<td>Exports of goods and services</td>
<td></td>
</tr>
<tr>
<td>OUTPUT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NET DOMESTIC PRODUCT/ Net value added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes less subsidies on products</td>
<td>GENERATED INCOME, NET</td>
<td>Property incomes, current taxes (income, assets…), current transfers</td>
<td></td>
<td>Property income, current taxes and current transfers from RoW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of income (institutional sectors)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NET DISPOSABLE INCOME</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.3. The detailed NAM can be turned into a SAM by further expanding the cells and introducing more detailed social and demographic characteristics into the NAM sub-matrices. A SAM is constructed using several basic sources of economic information: the economy’s input-output table, the national accounts, government budgetary accounts, balance of payments and trade statistics. More specifically, a SAM elaborates the interrelationship between economic and social statistics by linking together the (mainly) macro-statistics of national accounts with the (mainly) micro-statistics of the labour market (eg occupations, gender, earnings, education, hours worked) and of households (eg. expenditure data, age, education, income distribution, transfers). This broadens the analysis considerably beyond national accounts (European Commission, 2003). The choice of the classification depends on the analytical purposes of the proposed SAM.

5.4. The accounts included in SAM often differ across CGE models-in the number of industries, factors of production or household types. SAM can be easily extended to include other flows in the economy and disaggregation into as many sectors as required. Larger and more complex SAMs may require larger survey samples to reliably fill in a larger number of SAM cells. Given modern-day computer technology, a larger and more complex SAM is not likely to make a simulation model significantly more complicated. It will, however, make the analysis of economic impacts of tourism shocks richer, with a heightened focus on how greater attention to economic realities influences model simulations (Flores, 2010).

5.5. Rather than construct a SAM from scratch, many models use the global CGE model database developed by Global Trade Analysis Project (GTAP) <https://www.gtap.agecon.purdue.edu>. The model database, with data contributions from CGE modellers around the world, provides the values of exogenous variables and parameters and the initial equilibrium values of all endogenous variables. The database is typically maintained in a computer file separate from the CGE model which is written in general functional notation. This approach makes it easier for the modeller to use the same general CGE model but swap databases when the country, sectors or factors under study change. Modellers can use GTAPAgg, a freeware program developed by Horridge (2008) and available from the GTAP project to aggregate the global database to smaller sets of regions and industries that are relevant for their research.

5.6. The conventional I-O table or SAM does not present tourism expenditure data explicitly. Final demand data in the CGE database include both tourism and non-tourism data for the same final demand category. As a result, tourism impact analysis using the conventional CGE database will not be able to capture the impact of tourism shocks on non-tourism industries for the same
commodity. The most credible data source for data on tourism demand and the supply of tourism industries is a national or regional Tourism Satellite Account (TSA). A TSA is a necessary tool to adapt I-O tables and national accounts (and thus SAM derived from them) to tourism specificities. TSAs are constructed using a combination of visitor expenditure data, industry data, and Supply and Use Tables (SUT) in the system of national accounts. TSAs provide detailed production accounts of the tourism industries, including data on employment, and linkages with other productive economic activities. They enable the relationships between tourism and other economic activity to be explored within the national accounts framework, extracting all the tourism-related economic activity which is included in the national accounts but not identified as tourism. TSA comprise a data source much richer than is typically available for services sectors of the economy. TSA provide detailed data on tourism activities that are not otherwise available in national accounts because national accounts provide data classified according to production activities and commodities, and tourism spans many of these standard classifications (TSA RMF, 2008). CGE models developed for tourism industry analysis now increasingly include tourism data from TSA providing a consistent means of modelling tourism’s economic impacts. Modellers have incorporated the tourism sector into the CGE framework more explicitly in recent years (Dwyer Forsyth, Spurr and Ho, 2003; Blake et al., 2006; Pham and Dwyer, 2013).

5.7. Tables comprising the TSA provide information inter alia on:

- **Production of Tourism Industries and All Other Industries.** The TSA Production table provides a “make” matrix showing the output of each commodity in each industry and a breakdown of costs by industry into three categories: intermediate inputs, compensation of employees, and other value added;

- **Supply and Consumption of Tourism and All Other Commodities.** This TSA table provides a breakdown of total supply of each commodity into various categories – such as domestic production, imports government sales; and a breakdown of demand into categories – intermediate, personal consumption, investment, exports and government expenditures;

- **Tourism Demand by Type of Visitor.** This table provides expenditures on each category by visitors, broken down into the following categories: business, government, resident and non-resident;

- **Tourism Employment and Compensation of Employees.** Using the tourism industry ratio, this table derives tourism employment and compensation of employees by industry.

**5.2 Equations in the CGE Model**

5.8. There are four types of equations in the set which are solved simultaneously (McDougal, 1995):

- **Equilibrium conditions** for each market ensure that supply is equal to demand for each good, service, factor of production and for foreign exchange. Resource allocation is via market forces. Assuming flexible prices and wages enables factors of production, such as labour and capital, and foreign exchange markets to be modelled;

- **Income-expenditure identities** ensure that the economic model is a closed system. Closure rules place aggregate constraints on the economic activity simulated in the CGE model. They pertain to how the three major macroeconomic accounts (government, trade, and capital accounts) adjust to regain equilibrium in response to changes in economic activity.
Closure rules establish the mechanisms for keeping the three major macro-accounts in balance after a change in economic activity. These rules have an important effect on the way a policy change works through the economy;

- **Behavioural relationships** state how economic agents (consumers, suppliers, investors and so on) acting in their own best interests can lead to changes in price and income levels. Businesses will seek to maximize profits subject to the constraints of technology. The household buys bundles of goods to maximise a utility function subject to a household expenditure constraint. Optimising behaviour also determines industry demands for labour and capital. Not every sector needs be modelled in terms of optimising behaviour - the government and foreign sectors are often given a more flexible systematic treatment;

- **Production functions** determine how much output is produced for any given level of factor employment. With assumptions regarding market structure, these determine what levels of labour employment, capital usage and intermediate input usage are required to satisfy a given level of output for a given set of prices. Firms in each regional sector are assumed to choose the mix of inputs which minimises the costs of production for their level of output. The production assumptions allow substitution between intermediate inputs and factors of production as prices and wages change. The responses of industries to changes in prices are governed by functions that specify the elasticity of substitution between inputs, and output functions that specify the elasticity of transformation between outputs.

### 5.3 Behavioural parameters/elasticities

5.9. After all information about the expenditures and revenues and the interactions of all agents have been included into a SAM, the modeller needs to provide the value of the exogenous parameters (called behavioural parameters) that characterize the behaviour of producers and consumers. These parameters measure the responsiveness of producers and consumers to relative price and income changes and therefore have an important bearing on the outcome of a CGE simulation. The parameter settings may be determined on the basis of econometrics, literature search, expert opinion or judgement. “Policy” parameters, such as tax rates and government assistance-program rules, are determined by government policy. “Share” parameters, such as household expenditure shares, savings rates, and producer input shares, are derived from microsurvey data and data from national accounts. “Elasticity” parameters, such as those for labor supply, household consumption, and production, characterize the behavior of households and producers in response to changes in prices (wages) or income. Values for the elasticity parameters come from economic and social science research (Shoven and Whalley, 1992; Harrison et al, 2000).

### 5.4 Calibrating a model

5.10. The final stage for operationalizing a CGE model consists in calibrating all the remaining unknown parameters. Calibration involves choosing the values of a subset of the parameters in such a way that together with the assembled SAM and the values of the behavioural parameters, the model is able to reproduce exactly the data of a reference year – the baseline. All simulations of the CGE model will be based on a comparison with this baseline.
5.5 Assessing CGE Simulations

5.11. Once the model has been calibrated, it can be used to simulate the effects of some proposed change. The purpose of CGE simulations in tourism analysis is to determine the effects of a change in tourism policy or exogenous shocks on the endogenous variables of the model – prices, production, consumption, exports, imports and welfare. The modeller creates ‘disequilibrium’ by changing an exogenous variable in the model. Thence all of the CGE model equations must be re-solved to find new solution values for all of the endogenous variables in the model. The new values represent a new equilibrium in which the supply is again equal to demand at some set of prices. The simulation represents what the economy would look like if the policy change or shock had occurred. The difference in the values of the endogenous variables in the baseline and the simulation represents the effect of the policy change.

5.12. In order to obtain a solution to the model, the model’s equations are solved simultaneously. However, CGE models usually have more variables than equations, which means that the user must specify the values of some variables. This set of user-specified exogenous variables is referred to as the model’s closure. The way in which equilibrium relationships are obtained in CGE models, or how the models are ‘closed’ is important. A wide range of model closures is available for a CGE model. No single set of closure rules is generally applicable; the appropriate closure depends upon the economy being studied and the assumed time horizon. In general, one should consider both the economic environment and the time span of the simulations (Burfisher, 2011).

5.13. There are a number of ways to instil greater confidence in these simulation results. One is with sensitivity analysis. This involves changing the model’s parameters, or specifications, to determine whether the simulation results are significantly affected.

5.14. The majority of CGE models are formulated and solved using mainstream software systems such as AMPL, GAMS, GEMPACK or MATLAB. These systems use multi-step processes to generate exact solutions of the underlying, non-linear, equations, as well as to compute linear approximations to those solutions (Dixon and Rimmer, 2002).

5.6 Static Vs Dynamic Modelling

5.15. CGE models can be separated into two broad categories, comparative static and dynamic.

5.16. A comparative static model compares the economy at two distinct points in time, without modelling any explicit time periods or time path. In comparative-static mode, the effects of the specified policy change can be estimated over a short-run or long-run time span, depending on the closure chosen. This method of analysis does not provide any details of the adjustment path of the economy between the two points in time.

5.17. Dynamic CGE models explicitly trace each variable through time, often at annual intervals, so that the adjustment path of the economy can be examined. The path comprises a series of simulations, across a sequence of years, linked by inter-temporal equations describing investment decisions and capital accumulation (Blake, 2009). The model explicitly generates a time path of the economy following the change in the policy or introduction of a supply side or demand side shock. If agents’ expectations depend on the future state of the economy, it becomes necessary to solve for all periods simultaneously, leading to full multi-period dynamic CGE models which explicitly incorporate uncertainty about the future.
5.18. Although CGE models can simulate future effects of policy changes, they are not a forecasting tool. Policies are evaluated by comparing the economy between two states of the world. The pre-policy baseline is generated from the base year data and the impact of a policy is estimated by measuring deviations from the baseline following the policy change (Pratt, Blake, & Swann, 2013).

6. Applications of CGE modelling to tourism

6.1. CGE models are now increasingly used in tourism economics analysis and policy formulation. Some examples of topics addressed include: economic impacts of changes in inbound tourism; tourism effects on income distribution and poverty reduction; economic impacts of crises affecting tourism; economic impacts of climate change; economic impacts of special events; evaluation of economic policy on tourism industries.

6.1 Economic impacts of changes in inbound tourism

6.2. CGE models provide information on the structural effects of an expansion of inbound tourism. While an expansion in inbound tourism can generate an increased overall growth in real GDP, real exchange rate, real wages the Consumer Price Index (CPI) and net benefits or welfare, the modelling provides empirical evidence to support Copeland’s (1991) theoretical argument that some sectors benefit and some lose as the result of tourism expansion. CGE model simulations undertaken in both developed and developing countries have several outcomes in common:

- An Australian study (Adams and Parmenter, 1995) showed that sectors which gain from increased inbound tourism included service industries catering directly to international tourists (eg. air transport, restaurants and hotels) and industries indirectly supplying tourism-related activities (eg. aircraft maintenance and construction), while sectors which contract include non-tourism exporters (eg. agriculture, mining, food and metals processing), and import-competing industries (eg. transport equipment, chemicals, textiles, clothing and footwear);

- A study for Fiji (Narayan, 2004) showed that the gains to tourism related sectors (in hotels, transport, personal services) are offset to some extent by losses in traditional export and import competing industries, due importantly to a tourism induced appreciation of the currency;

- CGE modelling shows that inbound tourism contributes significantly to the Singaporean economy, competing with non-tourism sectors for resources (Meng, 2014). Inbound tourism causes a significant appreciation of the Singapore dollar and thus has considerable negative effects on its other exports. The results show that Singapore’s yield-driven marketing approach, targeted to maximise total visitor expenditure, may not necessarily maximise tourism’s contribution to GDP, employment and household income. This study confirms the results of CGE modelling in estimating the economy wide impacts of different tourism market segments compared to the simple expenditure yield measures that drive destination marketing in many countries (see also Dwyer et al, 2014).

6.3. Unless there is significant excess capacity in tourism-related industries, the primary effect of an economy-wide expansion in inbound tourism is to alter the industrial structure of the economy rather than to generate a large increase in aggregate economic activity, including income and
employment generation. Its effect will thus show up as a change in the composition of the economy rather than as a net addition to activity. The findings associated with particular countries are generalizable, suggesting that economic planners, especially those in developing countries, should be cautious before nominating the tourism industry as a key sector in the development process.

6.2 Economic impacts of tourism crises

6.4. Crises affecting tourism can take many forms. CGE modelling reveals many interesting and varied policy implications of external events affecting tourism demand or supply.

- A study of the economy wide effects of Foot and Mouth Disease (FMD) in the UK (Blake, Sinclair and Sugiyarto, 2003) found that the policy of maintaining FMD-free status supported meat exports at a substantial cost to the UK tourism industry. A policy geared towards supporting tourism would have been far less costly than the government’s policy of supporting agricultural exports by means of slaughtering animals and prohibiting access to many rural areas. The implication is that policy makers, including DMOs need to adopt a ‘whole of industry approach’ to decisions relating to FMD and in formulating agricultural policies;

- A CGE model was used to estimate the impacts on tourism in the USA of actual and proposed policy responses of the US government following the terrorist attacks of September 11, 2001 (Blake and Sinclair, 2003). Major findings were that an airline production subsidy and subsidies to accommodation establishments are reasonably effective at boosting GDP and saving jobs in both sectors. In contrast, subsidies to catering and entertainment can worsen GDP and labor and capital adjustment, as they encourage workers to move out of the airline and accommodation sectors, thereby increasing the job losses in these sectors. The study can help to inform DMO to develop options for future crises affecting tourism;

- Berrittella, Bigano, Rosona, and Tol (2006) studied the economic implications of climate-change-induced variations in tourism demand, using a world CGE model. The impact of climate change on tourism is portrayed by means of two sets of shocks, occurring simultaneously. The first shocks translate predicted variations in tourist flows into changes of consumption preferences for domestically produced goods. The second shocks reallocate income across world regions, simulating the effect of higher or lower tourists’ expenditure. The analysis highlights that variations in tourist flows will affect regional economies in a way that is directly related to the sign and magnitude of flow variations. At a global scale, climate change will ultimately lead to a welfare loss, unevenly spread across regions;

- A multi-regional CGE model for Indonesia was employed to estimate the short-run effect of a decline in tourism following the 2002 Bali bombings on the Indonesian economy (Pambudi et al, 2009). Within Bali the tourism-related and non-tradable sectors contain the worst affected industries while export-oriented industries, such as textiles, clothing and footwear, and import-competiting industries, such as machinery and electronics expand. To have most effect, policy-makers and lending agencies should take into account not only the regional macroeconomic implications of a crisis affecting tourism demand, but also the sectoral results in allocating compensation packages;
Although the SARS crisis resulted in less inbound tourism to Australia, it also reduced outbound tourism flows. Using a CGE model of the Australian economy, simulations of the impacts of SARS showed that the net effects on the destination were not as severe as were perceived by tourism stakeholders (Dwyer, Forsyth, Spurr and Ho, 2006). The net economic impacts on the nation depend upon the extent to which cancelled or postponed outbound travel are allocated to savings, to domestic tourism, or to the purchases of other goods and services. The results indicate that substitution effects must be taken into account in estimating the impact of some adverse situation on the economic contribution of tourism to a destination;

- CGE simulation of the effects of the Global Financial Crisis (GFC) on Singapore (Meng et al., 2010), demonstrate that at the macro level, the GFC tends to have large negative effects on the Singapore economy. At the industry level, a negative tourism shock impacts severely on the tourism-related sectors, impacts only slightly on sectors weakly linked to tourism, but tourism-competing sectors expand. In the labour market, low skilled workers are adversely affected, but some occupational groups benefit at the expense of others. The results can help DMOs to develop policy options for any future financial crises.

6.5. Studies of crises using CGE models reveal that crises affecting tourism affect other industries as well and the total impact must be considered in formulating policy responses. CGE modelling provides valuable input into policy formulation with its identification of gainers and losers from exercise of different crisis responses.

### 6.3 Economic impacts of special events

6.6. A dynamic CGE model of the UK and London economies was used to forecast the economic impacts of the London 2012 Olympics (Blake, 2005). While the overall impacts on GDP and employment in the UK are positive, the simulations reveal that there would be a loss of GDP and employment in the areas outside London. Similar results were found for the Formula One Grand Prix in Melbourne where positive economic impacts on the host state were almost totally offset by losses in states comprising the rest of Australia (Dwyer et al, 2004). The London Olympics study also shows that the impact of the Games varies significantly across different sectors of the UK economy. Sectors that expand include construction, passenger land transport, business services, hotels and restaurants. Sectors that contract include manufacturing, agriculture, fishing and other services. CGE modelling indicates that in a developed country, a mega event, even of the size of the summer Olympics, is unlikely to provide any substantial boost to either the national or host-region economy.

6.7. A multiregional CGE model was used to examine the effects of a mega sporting event, the Sydney 2000 summer Olympics (Madden, 2006). Simulations were conducted for three phases over a 12-year period. The degree to which this positive impact comes at the expense of other states was found to depend crucially on assumed labour-market conditions.

6.8. CGE modelling of the 2010 Football World Cup showed that the event would positively impact on the economy of South Africa in terms of GDP growth and employment especially in the service sectors, with negative effects that include higher inflation and net export losses overall (Saayman & Rossouw, 2008). A study by Bohlmann and van Heerden (2008) using different assumption sets concluded that, overall, the effects on GDP and employment are positive but small. These gains were found to be driven mainly by unskilled unemployed resources that were drawn into economic activity by the demand injection.
6.9. CGE modelling was used to assess the economic impact of the Beijing Olympics (Li, Blake and Thomas, 2013). The welfare impacts of the Beijing Olympics under imperfect competition are shown to be higher than when perfect competition is assumed. This is explained by the pro-competitive effect as new entrants to the market drive down levels of mark-up on marginal costs leading to an increase in efficiency. The benefits of tourism were found to be lower when a tourism boom is anticipated. This suggests that static analyses of major events will not capture their economic effects as fully as dynamic modelling.

6.10. Use of CGE models to estimate the economic impacts of special events has revealed many outcomes that would not have emerged using I-O models, which until recently have been the standard technique used by tourism researchers. CGE modelling provides, in principle, much more accurate estimates of the ‘return on investment’ from public support for special events as well as identifying winners and losers in different regions and sectors.

6.4 Evaluation of economic policy

Employment Creation

6.11. Tourism strategies often identify employment creation as an important aim of industry development. Labour markets can be modelled in various forms, with the possibility of allowing for unemployment and skills shortages in different economic sectors CGE modelling (IAC, 1987; Dwyer and Forsyth, 1998), shows that the impacts of tourism growth on employment varies according to the causes of any existing unemployment, the efficiency of the labor market in terms of real wage flexibility, changes in the real exchange rate and the labor intensiveness of different sectors in the economy affected by tourism spending and government fiscal policy. There is little effect on unemployment when existing unemployment is structural or regional in nature since real exchange rate changes will alter the composition of existing industry in a way that offsets the gross employment gains to the tourist industry.

Taxation Policy

6.12. The impact of different types of taxation have been studied using CGE models developed for Spain (Blake, 2000), Mauritius (Gooroochurn and Milner, 2005), USA (Blake et al, 2001) and Australia (Forsyth et al, 2014). In the Spanish study, marginal increases in taxes on foreign tourism are likely to result in higher domestic welfare, since the effect of the increases is to reduce the pre-existing distortions in the Spanish economy that result from low levels of domestic taxation. The Mauritian study concluded that the structure of indirect taxation in Mauritius is not optimal and that tourism-related sectors appear to be under-taxed. Consideration of the distributional effects of an increase in sales tax on the tourism sector indicated that an increase in the tax rate has smaller adverse effects on poorer than on richer households. For the USA economy, removing all indirect taxes and replacing them with non-distorting direct taxes leads to an improvement to GDP of $528.4bn, which is 2.1% of GDP in 1997 (Blake, Durbarry, Sinclair, and Sugiyarto, 2001). It was found that overall, tourism and travel sectors experienced a smaller GDP increase than the national average implying that these sectors have levels of effective taxation that are higher than the national average. Study of the impacts of Australia’s Passenger Movement Charge, a tax on all persons departing Australia, show that while the tourism industry loses, there is a net positive impact on the economy as a whole. This comes about because of the tax effect- Australia gains from foreign tourists paying Australian taxes rather than Australian residents. This result contrasts with studies done in other countries of air passenger duties using I-O approaches.
Poverty Alleviation

6.13. Standard CGE models can be expanded to include different skill categories of labour and different households groups according to geographical location, income category, or other classification, allowing the distributional effects of tourism or tourism policies to be examined. Distributional effects from CGE models can be examined using the Lorenz curve, or the Gini coefficient.

6.14. A study for Brazil (Blake, Arbache, Sinclair and Teles, 2008) concluded that the structure of earnings in non-tourism export sectors plays a significant role in determining the net poverty effects (via changes in prices, earnings and government revenues) of increased inbound tourism. A study for Thailand revealed that inbound tourism expansion raises incomes across the board, but the main share of the gains accrues to the non-poor, given the distribution of factor ownership across household groups (Wattanakuljarus and Coxhead, 2008). The finding highlights that additional policy instruments are required to correct for the inequalities in income distribution in Thailand resulting from tourism growth.

EU Accession

6.15. Researchers developed CGE models of the Maltese and Cypriot economies to quantify and compare the impact of EU accession and changes in tourism on each of these Mediterranean islands (Blake, Sinclair and Sugiyarto, 2003). It was found that the effects of accession on tourism are negative in Malta and positive in Cyprus, because the greater effects from trade and funding allocations lead to a greater demand for factors of production in Malta that increase wage rates and take factors of production away from tourism. In Cyprus, effects that benefit tourism outweigh such general equilibrium trade-off effects.

Environmental Policy

6.16. CGE modelling now plays an important role in modelling the impacts of environmental policy (Conrad, 2002). To date, only a few studies specifically address tourism issues.

- Based on the MMRF-GREEN model, researchers investigated the potential economic impacts of introduction by the Australian government of its now abandoned Carbon Pollution Reduction Scheme, a cap and trade mechanism for reducing greenhouse gas emissions in Australia (Dwyer et al., 2013). Under the proposed scheme, the tourism sector would contract with falls in real tourism gross value added and tourism employment. While most tourism industries experience contraction in their real value added relative to baseline values, the rail transport industry experiences an expansion because the emissions price causes substitution toward this industry against the high-emissions transport industries such as air, water and other road transport industries.

Industry Policy

6.17. The effects of changes in a wide range of forms of government industry assistance to tourism can be modelled. This includes the capability of varying actual or implied rates of import tariffs, production subsidies and export subsidies.

- Depending on the industry mix within an area, tourism growth may increase or decrease Gross Regional Product and employment in that area. The simulations for tourism growth at regional level in Australia indicate that a State government that simply maintains its market share of a growing market may experience a fall in its GRP and overall
employment, depending on the composition of its industry. Due to appreciation of the exchange rate, three heavily (non-tourism) export oriented states in Australia were found to be net losers from general tourism stimulation nationally (Adams and Parmenter, 1999) – an unexpected result. This finding would not have been revealed in the absence of a regionally disaggregate CGE model;

- Mining as an export industry competes with other sectors of an economy for labor, capital and goods and services, thereby pushing up prices and the exchange rate. CGE modelling was used to assess impacts of the mining boom on the Australian economy and tourism in particular, through two broad mechanisms: an income effect and a price effect (Forsyth et al, 2014; Pham et al, 2015). The boost to household consumption provided by the boom through increased mining revenues supports increased demand for leisure tourism generally. These gains are offset, however, by reduced inbound tourism and increased outbound tourism resulting from the higher value of the Australian dollar. ‘Crowding out’ effects are most apparent for those parts of the tourism industry with greater dependence on leisure travel in the mining states, where competition from mining-related business travel is most intense, and in segments of the domestic industry which compete most directly with outbound travel.

6.18. While the studies highlighted above comprise only some of the research by tourism economists using CGE models, they indicate the types of issues that are being addressed in the literature. The results of the modelling are sometimes surprising and indicate the value of using this sophisticated approach to impact analysis rather than standard I-O modelling. While it is likely that many of the results are generalizable to other countries worldwide, the extent to which this is the case can only be determined by future studies that take account of the circumstances of different destinations. The relevance of the above findings go beyond their immediate interest to tourism economists. CGE studies that have been undertaken demand the attention of tourism planners and tourism marketers as well as public policy makers. A number of lessons can be learned regarding the advantages of CGE for tourism analysis and policy formulation.

7. Better insights through CGE Modelling

7.1. CGE models are now increasingly used in tourism economics analysis and policy formulation. Some advantages are:

7.1 Flexibility

7.2. CGE models possess a significant advantage in flexibility over other forms of modelling in specifying how economic agents react to changes in the economy. CGE models can be applied to any combination of demand and supply-side shocks, under a range of alternative macroeconomic environments and policy scenarios. CGE models are helpful to tourism policy makers who seek to use them to provide guidance about a wide variety of ‘What if?’ questions, arising from a wide range of domestic or international expenditure shocks. A strength of CGE analysis is that many of its assumptions can be varied and the sensitivity to them tested. The discussion of tourism applications of CGE modelling demonstrate the wide range of contexts in which this technique can be employed.
7.2 Microeconomic Information

Researchers are incorporating more microeconomic information into CGE models of tourism, providing improved policy analysis. In particular, econometric modelling is providing ever more accurate estimates of the parameter values that are included in CGE models, relating to more disaggregated levels of analysis. With the substantial increases in computing power and the availability of solution algorithms for large nonlinear equation systems, CGE models with great sector detail became solvable and can accommodate national accounting data in detail. Microsimulation models linked to CGE models can make a significant contribution to the evaluation and implementation of public policies that reduce income inequalities within and between destinations. Improved data at the regional and local levels would assist more effective policy formulation, along with better coordination between policy making at the local, regional, national and international levels (Jones, Munday and Roche, 2014).

7.3 Broader Perspective

Public policy makers and treasury officials at the national and state or provincial levels, who are concerned with wider policy and development planning issues, or with funding and resource allocation decisions affecting tourism, will be particularly interested in how the economy as a whole will be affected by changes in tourism numbers and expenditure, not just the tourism industry. CGE estimated destination-wide measures of tourism’s economic impact, after allowing for interactive effects, provide information unavailable on the other approaches (Dwyer et al, 2000, 2014).

7.4 Industry Mix

CGE studies reveal the essential interdependence between sectors in the development process. While the policy emphasis, in many developing countries in particular, has focussed on reducing leakages of tourist expenditure and the forging of stronger links between tourism and other sectors, the findings of CGE studies show the importance of the overall industry mix in tourism destinations, and its implications for tourism’s economic contribution to development (Pratt, 2015).

7.5 Market Distortions

The economy-wide framework associated with CGE modelling identifies various distortions that operate in the economy to influence the provision of tourism services and other goods and services. Some, such as restrictions on shopping hours, air service agreements, visa fees, discourage consumption of tourism services directly. Others, such as domestic taxes, restrictive labour practices, tariffs on imports and wage-cost loadings, operate to raise prices of tourist services indirectly and hence discourage their consumption. Use of CGE modelling can help determine the relative importance of such factors in influencing the economic contribution of tourism.

7.6 Extended Role for TSA

CGE models allow the full potential of the detailed data contained within TSAs to be realised in projecting tourism’s overall economic impact and in tourism policy analysis. Where a TSA is already in place, it will provide the statistical basis for much of the tourism specific data required in the development of any CGE model which contains an explicit tourism sector. The absence of TSAs in many countries helps to explain why, until recently, few existing CGE models identify a tourism
“industry” or incorporate any detailed breakdown of tourism data. Even where CGE models have sought to identify tourism, the absence of consistent definitions and data inputs from the national accounts has meant that their results have not been readily replicable or comparable from one model to another. The rise of TSA implies a greater role for CGE modelling in tourism policy analysis.

7.8. In much the same way that synthetic tourism satellite accounts are developed, a tourism sector, buying from other industries, can be set up within a CGE model, reflecting the expenditure patterns of different types of tourists. Developments in recent years have yielded models which have resolved the main difficulties, and which can be applied with confidence to tourism questions (Blake et al, 2006).

7.9. A CGE model, which is constructed with an explicit tourism sector in a manner consistent with the national TSA, and which draws on national TSA definitions and data, can provide an appropriate and cost effective tool for producing simulated TSA’s at the state/provincial level (Jones and Munday, 2008; Jones, Munday and Roche, 2014; Dwyer et al, 2003). If the assumptions and definitions adopted to build the tourism specific components of the CGE model are consistent with those of any official TSA structure then the resulting CGE generated TSA should be broadly consistent with what would be produced in a fully constructed TSA.

7.10. Although TSAs and CGE models play different roles in providing policy makers with insights into the economics of tourism, both are important and complement each other in the policy making.

7.7 Visitor Yield

7.11. The overall impact on an economy of different tourists from different origins, with different travel motivations and spending patterns determines the yield per visitor from different markets (Pratt, 2012). Economy-wide visitor yield measures derived from CGE modelling represent not only the ‘bottom line’ of the economic impacts of different visitor markets to any destination, but also form the basis for estimating the return on investment from additional visitor targeted marketing expenditure. In this respect, CGE modelling estimates of ‘yield’ per visitor provides a much more detailed basis for allocating funds to destination marketing than narrower approaches to determining per visitor yield (Dwyer, 2014).

7.8 Environmental Impacts

7.12. Recently CGE models have begun to make important contributions to modeling the impacts of international climate change policies in a CGE context (Nijkamp, Wang, S. & Kremers, 2005). With some exceptions (Berrittella et al, 2006; Dwyer et al, 2013) CGE based analysis of climate change in tourism and the evaluation of mitigation policies and adaptive behavior of tourism firms has been neglected.

7.13. Environmental externalities can be incorporated to show the effects of tourism and tourism policy on environmental issues. CGE models can link with environmental impact models, to evaluate the environmental impacts of tourism, such as on greenhouse gas emissions, energy use and ecological footprint (Lundie, Dwyer and Forsyth, 2007). CGE modelling can provide essential input into determining the environmental impacts of tourism shocks including estimates of the effects on tourism’s carbon footprint. MMRF-GREEN (Adams et al, 2008) has been developed to estimate the greenhouse gas emissions associated with economic activity. Little research has been done to explore the role of ‘green’ CGE models in tourism policy analysis despite their potential to inform policy analysis in this area.
7.9 Welfare Measures

7.14. CGE models can provide a net benefit or welfare measure. Unfortunately, tourism researchers continue to confuse the ‘impacts’ and the ‘benefits’ of tourism growth, ignoring the fact that tourism growth has an economic cost, since it requires the use of scarce resources. Recognising that changes in GDP, income and other economic variables are ‘gross measures’ of impacts, not benefits, researchers have introduced explicit measures of economic welfare into CGE modelling of tourism impacts. Welfare measures indicate how much better or worse off an economy is as a result of a tourism demand shock. To gain a welfare measure, Dixon adjusted GDP simulations to include the cost of capital, a procedure followed in a study of Australian tourism (Dwyer et al, 2003, 2010). Blake (2010), consistent with economic theory, measures a change in welfare by equivalent variation (EV), which indicates how much the change in welfare is worth to the economy at the pre-simulation set of prices. This welfare concept has been employed in various tourism studies including projected effects of the London Olympics 2012 (Blake, 2005) and the poverty reduction potential of tourism to Brazil (Blake et al, 2007). There is scope for greater use of welfare measures in CGE modelling of tourism impacts for greater policy relevance.

7.10 Trade Policy

7.15. Foreign trade can be treated in several different ways, to enable the modelling of small and large countries and has a decisive influence on the outcomes of policy simulations. Little research has explored the impacts of international trade policies on tourism. Tourism studies could focus more on different model structures for small and large countries with attention to the demand and supply for exports and imports.

7.11 Aviation/Tourism Nexus

7.16. Aviation policies can impact on tourism flows and expenditure, and thus they will have impacts on the economy. CGE models can be used for analysing a broad range of aviation issues. When considering proposed strategic alliance between airlines owned by different countries one of the key issues which policy makers will face will be that of whether it stimulates tourism, and if so, what are the benefits. These benefits will need to be set against any costs to the economies associated with the alliance. CGE modelling provides a means of assessing the impacts of aviation alliances or blue skies policies on output and employment, and the net benefits which result. CGE modelling of aviation impacts on tourism in destinations holds promise to provide valuable input into aviation policy (Broecker and Mercenier, 2011).

8. Addressing Concerns

8.1. Several types of criticisms continue to be levelled against the use of CGE models by tourism researchers. While some have a degree of validity, many of these criticisms are not specific to CGE but relate to modelling in general. Others appear to be based on confusions as to various features of CGE modelling or else are offered to bolster support for standard I-O modelling in tourism - a position that the economics profession worldwide would reject. Some common criticisms follow, together with the type of response which CGE modellers would offer.
8.1 CGE modelling is too difficult to use

8.2. Specific training and knowledge is required to construct and employ CGE models as noted below, but this is the case for any type of sophisticated modelling. Previously, implementation of general equilibrium analysis was constrained by inadequate data and computational resources. However, substantial progress has been made in the development of user-friendly, readily transferrable high capacity computer software, which has greatly increased researchers’ ability to handle models with considerable detail with application to actual market situations. Standard software capable of completely fitting the data, calibration and equilibrium calculation sequence are now routinely available. These include GEMODEL, GEMPACK and, especially, GAMS, with all their different solvers, or problem-solving algorithms adapted to the different model necessities (database sizes; multiregional, dynamic or static models, etc.). An increasing number of dynamic CGE models are now being developed, in line with improvements in software and increasing computational power, substantially facilitating simulations and shortening run times. Initial tests can be run more quickly to produce better simulation design and time to check results and the verify model theory and data.

8.2 CGE models are expensive to develop

8.3. Building new models may be time consuming, but is not an especially demanding exercise; PhD students regularly build them. CGE models can either be quite basic, incorporating a few sectors and the links between them, or very detailed. Given the relative simplicity of the basic model, readily available online, different application can easily be developed at relatively low cost to suit the needs of various studies. The use of mainstream software systems such as AMPL, GAMS, GEMPACK or MATLAB, has lowered the cost of entry to CGE modelling, allowing model simulations to be independently replicated, and increasing the transparency of the models. By far, most of the effort and cost of conducting tourism-impact simulations involves the construction of SAMs. Given a well-constructed SAM, a CGE model for tourism simulations can be constructed in a relatively short time.

8.4. Of course, estimating the economic impacts of tourism demand shocks in certain contexts may not justify the expense of constructing a new CGE model if no suitable model already exists. The practical advantage of using an alternative technique in certain tourism contexts is, however, a separate issue from its theoretical status.

8.3 CGE outputs are difficult to understand

8.5. All models provide a simplified representation of reality but nevertheless may provide an effective means of understanding and/or predicting economic interrelationships and outcomes. Results from CGE models can be explained clearly in terms of straightforward economic mechanisms and properties of the data incorporated in the model. It is the responsibility of the modeller to produce such explanations for the users of the results. To avoid any implication of CGE models being a ‘black box’ of technical data and equations serious concern should be given to interpretation and scenario building.

8.6. The same as for any modelling exercise, ‘communication breakdown’ may develop between modellers and users (policy makers). Ideally CGE modelling should not be a one-off event but should involve an interactive process whereby modellers and users exchange views on modelling objectives and expected outcomes as well as on the assumptions driving a model. As Flores (2010) has argued, the usefulness of and familiarity with CGE models increases in direct proportion to their use within specific policy oriented programmes.
8.7. Productive interactions between modellers and users and associated learning effects, seems to characterise an increasing volume of policy analysis on a wide range of topics (de Miguel, 2010), and agencies as ECLAC, IDB or the World Bank play a major role in supporting and encouraging collaborative approaches. Much could be accomplished in respect of tourism analysis if research centres with permanent staff dedicated to modelling tourism impacts were to be developed to take account of the potential synergies (eg. Australia’s now disbanded Sustainable Tourism Cooperative Research Centre which developed a suite of policy analyses using tourism CGE models <http://www.crctourism.com.au/and the former Christel DeHaan Tourism and Travel Research Institute at Nottingham University Business School).

8.4 CGE modelling is too data demanding

8.8. In reality, a CGE model is no more comprehensive than a SAM multiplier model, except that it is more flexible in terms of the way in which responses of economic agents are modelled. Once a SAM is completed, there is little reason, from a budgetary or time point of view, not to construct a CGE model, if impact analysis is required (Taylor, 2010).

8.9. The development of TSA provides an important source of tourism data as an input to CGE modelling obviating the need for detailed surveys of consumers and businesses. The use of an official TSA will often draw on expensive, specifically commissioned, surveys to fill data gaps.

8.10. It is true that data problems generally are severe at the regional level, a concern affecting all types of regional modelling, whether CGE or not. Regional CGE models obviously require considerable regional level data, which, in many cases, is difficult to obtain. Regional economic datasets, informed by regional location theory, are now being developed (Partridge and Rickman, 2010). Database construction methodology has progressed in recent years, allowing a multi-regional database to be constructed quickly, even with quite limited regional data (Horridge, 2012).

8.5 The data used in CGE modelling may be ‘out of date’

8.11. This problem confronts any modelling exercise, of course. Since the database of CGE models is heavily dependent on I-O accounts or SAMs, together with TSA data, the accuracy of its database is associated with the timeliness of such data. But so also is any alternative modelling technique that relies on this data. For many countries/regions I-O tables are updated every five years or so. In between years can be updated to GDP targets. How ‘dated’ the benchmark and modelling is will depend on the extent to which the economy being modelled structurally changes. There is no special problem regarding the timeliness or complexity of data for CGE modelling as such. Increasingly, statistical agencies throughout the world are attempting to deliver tourism data in a more timely fashion. Institutions such as the World Bank and GTAP emphasise the provision of timely data which is made available to modellers worldwide.

8.12. The data needs of CGE modelling are as great or as small as the analyst’s needs in any particular study. The building of SAM matrices including tourism activities and the application of CGE models to tourism economics, have recently become easier with the ongoing development of Tourism Satellite Accounts (TSAs) internationally. These have provided substantial increases in the quantity and quality of the data that can be used in CGE modelling. In contrast I-O modelling simply omits key data required for accurate impact analysis, avoiding making assumptions about how the rest of the economy works.
8.13. One of the more important criticisms levelled against CGE models is the quality of the information used to derive these behavioural parameters. Hertel (2007) has admitted that the history of estimating the substitution elasticities governing trade flows in CGE models has been "checkered" at best. Ideally, these parameter values should come with additional information (e.g. standard errors, functional form, etc.) which could provide some guidance about the reliability of these estimates, with adjustments being made accordingly.

8.6 There is no ‘standard’ CGE model

8.14. There are, of course, many types of CGE models in use worldwide that are informing policy makers in many areas including tourism. A major reason for a lack of homogeneity among CGE models employed in is the corresponding lack of a common and homogeneous SAM framework, even when the analysis ranges over similar problem areas and policy contexts. As noted above, inconsistent definitions and data inputs from the national accounts has precluded replicability of approaches and comparison of results of different tourism studies.

8.15. That said, the type of criticism advanced ignores the fact the CGE models share a basic core structure as outlined above. Extensions of the basic model exist for many of its policy applications, but this is a strength of the technique not a limitation. Most application-specific models are structurally simpler than general purpose models because they do not carry the ‘excess baggage’ of variables and equations that are not required for a particular application. Ideally, the structural details of models used for any application (parameter values, equation forms, input data vintage) should be explicitly identified and justified. This can facilitate the transfer of knowledge and of models to new users, and facilitates communication with non-modellers, who may wish to contribute to the model building process.

8.7 Model Validation

8.16. Another criticism is that CGE models are seldom validated against the real world situation. However, this problem is not inherent in CGE modelling. In economic modelling generally, there is room for much improvement, especially in the area of parameter estimation and in the development of more formal methods of testing model validity. More systematic validation of CGE simulations, through sensitivity analyses and ex-post evaluations, is needed to help improve confidence in the predictive value of the results. This can include analysis of the closure assumptions made, the model behavioural equations and econometric estimation of model parameters using micro survey data. Sensitivity analysis on parameters, data and closure can be facilitated by faster solution times as they involve running multiple simulations.

8.17. CGE models are sometimes claimed to be a ‘black box’ and criticised for their lack of transparency about assumptions and technical specifications of equations. There is some truth in this, but again the problem lies with the analysts not with the technique itself. Many CGE analysts are silent on details their equations and the scope of their calibration procedures. A possible cause of this communication failure may relate to weaknesses and inconsistencies of the accounting basis of the model (the supported SAM). Greater transparency as to the features of the SAM, including clear identification of data sources, can help to address this problem. In the case of tourism applications, this accounting improvement should be strengthened by an adequate integration of TSA elements in to CGE model.
8.8 CGE pretends to too much precision

8.18. The criticism is that CGE modelling pretends to a degree of precision in economic estimation that is, in reality, impossible to achieve. Again, this criticism applies to any form of economic modelling. It is acknowledged that standard CGE models do not often incorporate market failures. If markets do not clear and there are factor surpluses, then this can reduce the impact of prices and hence affect the efficient allocation of resources. But no model type can cover every contingency. Even if, in contexts of limited data, CGE analysis can only offer order of magnitude accuracy, the insights it brings to tourism impact analysis this may be more than other techniques can offer. There would seem to be no logic in applying models with less precise projections simply on this basis. The whole point of sensitivity analysis is to avoid the complacency of precision by developing an indicative range of results under different assumptions to inform policy making.

8.9 Working in Silos

8.19. The root cause of many concerns regarding use of CGE modelling in tourism lies in the lack of coordination and communication between different groups of experts. In practice, these experts work in two separate worlds. On the one hand, a dedicated group of researchers continue to focus on TSA, national accounts and I-O construction and modelling, with little or no interest in or expertise regarding CGE modelling. On the other hand, a second group of analysts focus on the conceptual basis and applications of CGE modelling to policy issues, attempting also to develop expert knowledge of the role played by TSA and SAM to inform the tourism database of their models. The relative lack of interaction and exchange between these groups is responsible for two major types of communication failure. The first communication failure relates to a lack of understanding by the first group concerning the power of CGE modelling as an analytical tool and its advantages over other modelling techniques for tourism policy analysis. The second communication failure relates to the failure of many CGE modellers to fully understand the power of TSA and SAM in providing credible and replicable databases as inputs to model construction.

8.20. Both communication failures can be overcome. The required attitude change depends on each group recognising the interrelationship between the two research areas and the potential synergies resulting from cooperative endeavour. An ideal outcome would be a greater effort worldwide to produce CGE models with databases adapted to tourism specificities. The cooperation would result in a general improvement of the quality of the models to the benefit of tourism research in varied destination and policy contexts. A complementary objective of this cooperation could be the design of a common worldwide-accepted ‘SAM’ framework that could be used by the different CGE teams. In this way, we can obtain more homogeneous and comparable CGE models to inform tourism policy and its analysis.

9. Skills Requirements for CGE Modelling

9.1. The skills for CGE modelling are not readily available even for those with economic/econometric university qualifications. However, expertise in CGE modelling globally has increased substantially in recent years in both government agencies and the private sector. Governments worldwide expect any claims of effects on economic activity of some proposed policy initiative to be made on the basis of analysis employing a CGE approach. This is particularly true of agencies with control over budgets such as Finance departments, and federal and state treasury departments. International financial institutions and agencies such as the World Bank, Asian Development Bank and Inter-American Development Bank have developed their own in-house
capabilities in CGE analysis, while smaller agencies rely on research centres and consultants for economic advice based on CGE modelling. The Centre of Policy Studies (CoPS), based at Victoria University in Australia, specializes in CGE modelling. CoPS undertakes academic/contract research and software development, conducts training courses in CGE modelling and offers graduate student supervision [http://www.copsmodels.com/index.htm]. An expanding number of staff in universities and Think Tanks around the world have CGE modelling expertise as evidenced by contributions to policy analysis in the journal literature.

9.2. CGE training courses are available, offered by both private and public education providers. The courses are typically of three types: Introductory, Dynamic, or Multi-Regional.

9.3. Training generally includes:

- Comprehensive documentation of all aspects of the models— theoretical structure, building databases, calibrating models, computational procedures, solving models, illustrative applications; interpretation and reporting;

- Facility in user friendly, readily transportable and low-cost computer software that can be used on desktop computers (eg. General Algebraic Modelling System (GAMS) or General Equilibrium Modelling PACKAGE (GEMPACK)).

9.4. Courses in CGE modelling are offered in various modes including classroom situations, online courses offering a collaborative learning environment, and custom programs individually tailored to suit specific individual and institutional needs. Institutions such as United Nations agencies, the International Food Policy Research Institute (IFPRI), the World Bank, Asian Development Bank and the IBD/INT CGE modeling services also include the provision of technical assistance and advisory services CGE capacity building to government agencies and companies in. Many training providers (eg Global Trade Analysis Project- GTAP), have consolidated regional and international networks of researchers through conferences, outreach publications and workshops.

9.5. The courses on offer also instruct students on how to adapt basic models to develop models for specific purposes and for particular countries and regions, including consulting services to assist or accelerate development of similar models worldwide. Short courses are available on constructing a CGE database. Trainee modellers can start by reading general introductions to CGE modelling (Burfisher, 2011; Cardenete, Guerra and Sancho, 2012). Breisinger, Thomas and Thurlow (2009) provide a good introduction to SAM, the databases that underlie CGE modelling. As skills progress modellers can read intermediate level treatments eg Hosoe, Gasawa and Hashimoto (2010).

9.6. Trainees typically are associated with international and national institutions (including tourism ministries), central banks, government agencies, universities, companies, and individual economists. The level of skills required for course entry do not include programming knowledge. Sophisticated Microsoft Excel interfaces allows scenarios to be solved using software that enables both specialists and non-specialists to use models to estimate the effects of their differing hypotheses about the range of alternative scenarios that may occur. Previous hands-on experience in solving GE models is not required. Ideally, course participants would have a bachelor or master degree in Economics or Econometrics or equivalent work experience, and facility in using a PC or notebook running Windows.

9.7. A substantial amount of information regarding model development and use is available on the internet. For example, the GAMS website at [www.gams.org] maintains a library of simple CGE models that can be downloaded and run using the free demonstration version of GAMS. As also
mentioned earlier, modellers can use GTAPAgg, a freeware program and available from the GTAP project to aggregate the global database to smaller sets of regions and industries that are relevant for their research.

9.8. ORANI-G (a generic version of the ORANI model originally developed for Australia) has proved an excellent starting point for the construction of other single-country models. Various researchers have adapted it to a number of countries including Denmark, Philippines, China, Korea, Indonesia, Sri Lanka, Malaysia, Brazil, Vietnam, Pakistan, South Africa, Fiji and Thailand. In conjunction with the full GEMPACK system, the ORANI-G.TAB file forms an excellent starting-point for constructing of a particular CGE model. This file is available from the internet <http://www.copsmodels.com/oranig.htm>. The most minimal change is to attach a different data file, appropriate to another country. Modellers can use the GEMPACK program to turn data in text files into GEMPACK’s binary format. The CRUSOE project extends the usefulness of ORANI-G with a freely downloadable set of national databases covering 78 countries or world regions.

9.9. As the above overview makes clear, various options are available for an organisation that wishes to undertake CGE modelling in tourism. A National or Regional Tourism Organisation, government agency or consulting firm possessing staff with CGE modelling expertise, could either purchase or develop in-house a CGE model for tourism policy analysis. A good starting strategy might be to use a model that works, such as ORANI-G, and add relevant country and regional data as required. Where a TSA is available, this provides a rich source of tourism information for the model. A promising option for some tourism agencies will be to partner up with either their national statistical office or other economic research institutes that have experience in using CGE models or the “national” CGE model for the country in order to develop a tourism CGE model.

10. Conclusions

10.1. Despite their widespread use in policy formulation worldwide, CGE modelling remains relatively under-used in tourism policy analysis. This report has sought to identify and discuss the key reasons why CGE modelling should be accorded greater attention by governments and their agencies, consultants and researchers associated with tourism analysis and policy. CGE modelling has great potential to inform policies that will affect the tourism industry within a country or region and can be applied to a much broader set of policy issues than at present.

10.2. The general equilibrium effects of changes affecting tourism demand and supply have long been recognised, but in earlier days it was not possible to handle them in empirical models. Now that computable general equilibrium models are available, we have at our disposal workable and flexible models that represent the whole economy and in which resource constraints and feedback effects are explicitly recognised. In a context of ongoing theoretical and practical development, CGE tourism modelling provides a versatile and effective means of examining the wide range of scenarios that can occur in both developed and developing destinations.
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The World Tourism Organization (UNWTO), a United Nations specialized agency, is the leading international organization with the decisive and central role in promoting the development of responsible, sustainable and universally accessible tourism. It serves as a global forum for tourism policy issues and a practical source of tourism know-how. Its membership includes 156 countries, 6 territories, 2 permanent observers and over 400 Affiliate Members.