CGE modeling for the economic assessment of mega-events: A tentative cookbook

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Abstract

This paper aims at making available an interpretative framework to cast the different contributions on the economic assessment of mega-events by means of a computable general equilibrium model. A taxonomy of existing models and approaches is carried out, to clarify to what extent the differences in results are due to the various modeling choices. Their differences and relationships are highlighted, while also providing a standardized reference for future studies. A computable general equilibrium modeling solution that can balance the need to keep the model simple and the need to understand if the hosting country obtains long-term economic gains is suggested.

Keywords: computable general equilibrium models, methodological issues, mega-events.

JEL codes: C68, Z28, Z38.

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1. Introduction

Besides traditional fields of employment, computable general equilibrium (CGE) models have also been applied to study the economic impact of mega-events, defined by Müller (2015) as "ambulatory occasions of a fixed duration that attract a large number of visitors, have a large mediated reach, come with large costs and have large impacts on the built environment and the population". Believed by policy makers as an engine to undertake the development path, create long-lasting economic benefits and attain international recognition, many cities, countries and emerging economies invested considerable public funds to host mega-events. Their proliferation has resulted in the need for a careful evaluation of the actual economic performance of such events and the real entity of the so-called "legacy".

After the pioneering contribution on the economic impact of the Sydney 2000 Olympics on the Australian economy by Madden and Crowe (1998), the number of studies using CGE models has been steadily increasing. These contributions typically analyze the impact of international large sport events, like the Summer Olympic Games (Madden, 2006; Blake, 2005; Giesecke and Madden, 2007, 2011; Li et al., 2011; Li et al., 2013), the FIFA Soccer World Cup (Bohlmann and van Heerden, 2005, 2008; Saayman and Rossouw, 2008) and the Commonwealth Games (Allan et al., 2017).

Despite the methodology employed in these studies being similar, they often show diverse results, from a qualitative point of view. One may say that these divergences are due to some fundamental differences in the economic environment, as well as in the nature of events and shocks. This is only partially true as, for instance, studies carried out for the same mega-event highlight opposite findings, hindering the robustness and reliability of the economic analysis for policy guidance.

Two are the critical flaws one can detect in many studies. First, analyses are only partial: there is a multiplicity of economic effects generated by a mega-event, which are not simultaneously taken into account. Indeed, many studies focus only on a limited set of effects; second, they fail to recognize that almost all shocks generated by a mega-event are comparable with other shocks originated in different contexts, whose consequences are perhaps better known and more thoroughly investigated.

The multiplicity of shocks generated by a mega-event can be summarized into two broad categories, whose economic consequences are known but not fully taken into account in most existing studies: (i) expenditure effects (e.g., public expenditure increase, changes in international tourism expenditures) and (ii) productivity effects (e.g., improved competitiveness of domestic goods and services in international markets). For example, the improved competitiveness generates what is known in the economic literature as the "Dutch disease": higher competitiveness in some industries causes lower competitiveness elsewhere in the economy. A second example is the change in the patterns of consumption and investment: this structural change is simply a demand shifting. In this respect, modeling choices (e.g., closure rules) that are key for the results in other demand-driven simulation exercises turn out to be critical for the assessment of mega-events as well.

This paper aims at making available an interpretative framework to cast the different contributions, their differences and relationships, while also providing a standardized reference for future studies. In particular, taxonomy of existing models and approaches will be carried out, to clarify to what extent the differences in results are due to the various modeling choices. An illustrative standard CGE model is employed to this purpose.

To frame our analysis, studies on CGE modeling of mega-events are reviewed in the next Section, as well as the economic shocks associated with hosting a mega-event. In Section 3 the methodological issues arising when simulating a mega-event by means of a CGE model are discussed, and a modeling approach is suggested. The results of an illustrative simulation with a simple CGE model are presented in Section 4. A final section draws some conclusions.

2. CGE modeling of mega-events: background and major studies

Over the past 25 years the development and application of (computable) general equilibrium models has grown enormously and CGE models have become a standard tool of empirical economic analysis and policy assessment. While CGEs are extensively employed in many fields, most notably in international trade policy, public and environmental economics, their adoption in the field of mega-event assessment started at a later stage, when the literature recognized their potential to overcome the many the limitations associated with the long-established input-output (IO) models, commonly employed in this research field.

The discussion on the drawbacks of IO analysis dates back to Crompton (1995), who identified few typical problems in IO studies applied to sports events (e.g., the omission of substitution effects). Since then, there has been a growing literature recognizing that the assumptions imposed on the IO modeling system generate a systematic over-estimation of economic impacts (see, e.g., Dwyer et al. 2004, 2006; Jago and Dwyer, 2006). As Madden (2006) puts it: “the problems with IO analysis are of such a fundamental nature that it should no longer be used in the analysis of sporting ventures, particular not for mega-events of the scale of the Olympic Games”. With an assumed unlimited supply of factors, an implicit assumption of IO models is infinitely elastic supply curves. As such, IO models are the multi-sectoral equivalent of Keynesian macroeconomic models: the economy always finds the necessary resources to meet any increase in final demand, including the one triggered by investments for the realization of a mega event. There is no crowding out, and any increase in demand will yield only positive indirect effects. By ignoring this important aspect, a systematic over-estimation of impacts is clinched, because the potential negative economic impact induced by a positive demand shock cannot be measured. In fact, when more resources are required in one or more sectors of the economy, they are partially or totally drawn away from productive activities elsewhere in the economy (Dwyer et al., 2004). As the relative prices of inputs change, other activities are discouraged. The net impact on output and employment of a positive demand shock created by a mega-event is therefore smaller than the initial injection of expenditure. By construction, these downsides cannot be handled by an IO model, resulting in a likely overestimate of the final impact on the overall economic activity (Matheson, 2009). Furthermore, for temporary demand shocks, such as those associated with mega-events, the release of local resources may be important determinants of the overall economic outcome.

In this setting, CGE analysis has typically been favored (Dwyer et al., 2004, 2005).[1] Depending on the key relationships in the economy, the extent of this overestimation could be very large. Dwyer et al. (2005) estimate the economic impact of a major sport event (a car race) at the national level, using both a standard IO analysis and a CGE model which, by its very nature, is built to capture the matching of supply and demand in multiple markets, to account for resource constraints, displacement effects and feedback effects from all the markets of the economy. They find that net aggregate benefits computed with the standard IO model are about two times larger than those estimated with the general equilibrium model.

CGE models build upon the Walrasian theory of general equilibrium that draws on the key concepts of market clearing and neoclassical micro-economic optimization behavior of rational economic agents. A CGE model depicts the structure of an economy, by tracing the circular flow of income inside the economic system. It treats the economy as an integrated system, in which markets influence each other, resource are constrained, prices are allowed to vary and demand and supply must balance.[2] Its structure allows to cope with the complex sectoral interplay, to perform analyses of structural change, to analyze welfare impacts, as well as to explore second-order dynamics, including several distributional effects at play during the implementation of a mega-event project. From a mathematical viewpoint, a CGE is a quantitatively solvable large non-linear system, whose parameters are calibrated on real world data, like IO tables and social accounting matrices. The model system is solved with appropriate mathematical software, and counterfactual simulation experiments are typically carried out by changing exogenous parameters.

Since the contribution of Madden and Crowe (1998) on the economic impact of the Sydney 2000 Olympics, the number of studies using CGE models has increased. Most studies focus on international large sports events, like the Summer Olympic Games (Madden, 2002, 2006; Giesecke and Madden, 2007, 2011; Blake, 2005; Li et al., 2011; Li et al., 2013), the FIFA Soccer World Cup (Bohlmann and van Heerden, 2005, 2008; Saayman and Rossouw, 2008) and the Glasgow 2014 Commonwealth Games (Allan et al., 2017). Few papers analyze other international and national sport events, like car races (Dwyer et al., 2004, 2005) .

Some of these studies are particularly relevant to the purpose of this paper, because they quantify the sensitivity of results to different model specifications and offer a portfolio of simulation exercises; in some others a number of flaws hamper the robustness and reliability of the economic analysis. For example, in many studies the analysis is only partial: there is a multiplicity of economic effects generated by a mega-event, which are not taken into account (Li et al. 2011; Li et al., 2013; Allan et al., 2017). Second, CGE models employed are often run under the assumption of full employment of available resources, without considering the possibility that an expansion of demand may activate unused primary resources (Giesecke and Madden,

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[1] CGE analysis is also considered superior to other evaluation methods, like cost-benefit analysis. Dwyer and Forsyth (2009) argue that CBA cannot estimate e.g. the inter-industry impacts of an event, impacts on exchange rates, the shadow price of labor and capital. Andersson et al. (2008) and Li and Jago (2013) stress, instead, the critical assumptions needed behind the estimation of both the benefit- and cost-side of a CBA, especially regarding the quantification of non-economic elements. Finally, macro-econometric modelling cannot capture the interrelationships of different industries in an economy (Russo, 2009).

[2] This does not imply that in CGEs primary resources are always fully employed or that trade deficit/surplus are not allowed. This issue will be discussed in Section 3.

2007, 2011). As noted by Madden (2006), the way in which labor markets are modeled have a large influence on the results of CGE simulations. Third, they fail to recognize that almost all shocks generated by a mega-event are comparable with other shocks originated in different contexts, whose consequences are perhaps better known and more thoroughly investigated. The study by Blake (2005) on the 2012 London Olympics 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. This improved competitiveness in event-related sectors is an example of well-known phenomenon called the "Dutch disease": higher competitiveness in some industries causes lower competitiveness elsewhere in the economy.

A couple of works by Giesecke and Madden (2007, 2011) estimate the impact of the 2000 Sydney Olympics. They employ a recursive-dynamic multiregional CGE model, covering the Australia's eight states and territories, and identify three routes of direct effect on the economies of NSW (where Sydney is located) and Australia: (i) construction of the Games facilities and associated financing, financed via direct taxation of NSW households; (ii) operation of the Games; and (iii) tourism spending by interstate and foreign Games visitors. The papers by Giesecke and Madden are based on previous studies carried out by Madden (2002, 2006), who discusses in depth the effects of different modeling assumptions on simulation results. The simulation of the Sydney Olympics economic effects is done under alternative scenarios on increased exports demand (more or less optimistic) and labor market conditions (more or less tight) characterizing the three phases of the Games (i.e., pre-event, event and post-event, see Section 2.1). The author finds that the assumed degree of slackness in the short-run labor market and the portion of foreign demand in the direct Olympics expenditure are the major determinants of the size and sign of the impact.

While the studies on the Sydney Olympic Games agree that 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, Li et al. (2011) and Li et al. (2013) both analyze the economic impact of international tourism associated with the 2008 Beijing Olympics, but come up with qualitatively different welfare impacts. Furthermore, these studies neglect non-tourism expenditure, and this may generate a misunderstanding of the actual economic impact associated with the mega-event.

The extent to which differences in results are due to the model assumptions is also investigated by Li et al. (2013) and Allan et al. (2017). In Li et al. (2013) the CGE model is run under the assumption that firms compete in a Dixit–Stiglitz type of imperfectly competitive setting, and results show that the welfare impacts under imperfect competition are higher than when perfect competition is assumed. Allan et al. (2017) use a multi-period Scottish CGE model to estimate the system-wide effects of the temporary tourism expenditure related to the Glasgow 2014 Commonwealth Games. They quantify the sensitivity of results to different model specifications, focusing in particular on how investment and consumption decisions are made and shifted over time to accommodate the temporary tourism shock. They find that results are very sensitive to the degree to which economic agents are forward-looking and the extent of pre-announcement of the event.

The contributions by Bohlmann and van Heerden (2005, 2008) and Saayman and Rossouw (2008), who estimate the potential economic impact of the 2010 World Cup on the South African economy, deserve a discussion, too. The authors employ a CGE model developed specifically for the South African economy, and several simulation exercises are conducted to account for various impacts (i.e., infrastructure developments, increased tourism and financing implications). Despite they claim that "when interpreting the results it is important to be aware of the assumptions and restrictions under which the model is run" and "the simulation results of the shocks applied to the economy depend to a large extent on the model closure", no sensitivity analysis of results to model assumptions is conducted.

2.1. Economic shocks generated by a mega-event

The purpose of this paper is making clear how a meaningful CGE simulation of a mega-event shock should be done. The first step is determining the multiplicity of effects generated by a mega-event and the temporal distribution in which they occur. At this stage, it is very important to keep in mind that we are not focusing on a specific type of mega-event, like the Olympics or other major international sport events, but our analysis has an all-embracing perspective. The methodology this paper proposes can, in principle, be applied to any special event that intervenes to a significant degree in the host country, leaving long-lasting transformative socio-economic impacts (e.g., the EXPO, Jubileum, etc.). Figure 1 provides a simple illustration of the various shocks and their effects on the economy.

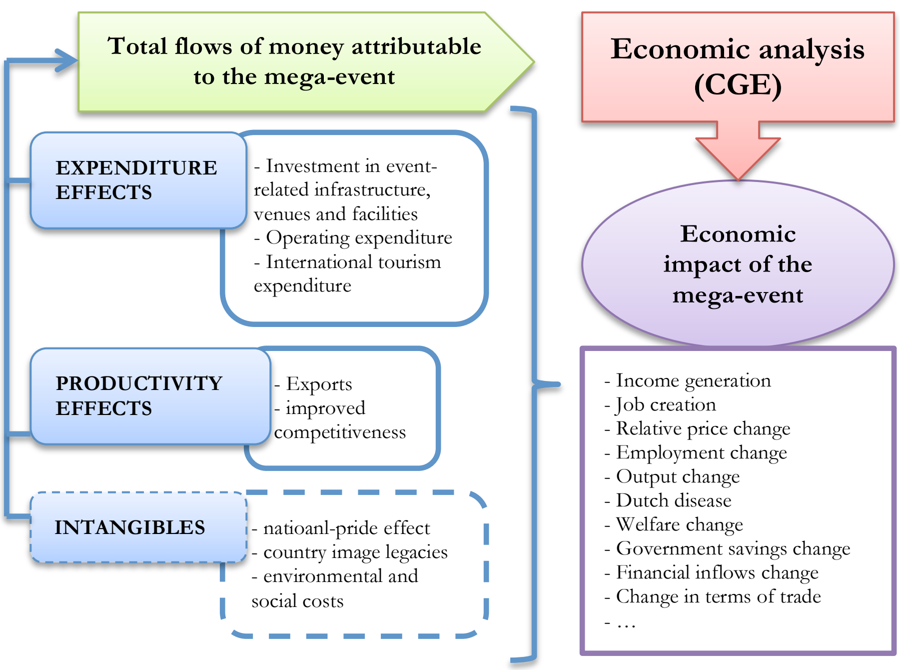

Figure 1. Economic shocks attributable to a mega-event and their effects on the economy.

Two broad categories can be identified, expenditure effects and productivity effects. On the expenditure effects side, some examples are: increase in investment to built or renovate side-infrastructure (e.g., transportation, information technology) and event-related venues and facilities (e.g., sport buildings in the case of sport events, other temporary facilities); increase in operation expenditures (e.g., ceremonies and programs, media and press center, security, administration and promotion); large temporary tourist inflows accompanied by increased tourism expenditure. The origin of expenditure and investment is distinguished between foreign, domestic private and domestic public sources. This distinction is important to accurately estimating the income and welfare effects generated by the mega-event, because only foreign expenditure/investment are new money injected into the host economy, while the other two are just national transfers from other alternative uses (Li, 2012). In other words, without holding the event, event-related foreign expenditure/investment would not be generated, whereas domestic private and public expenditure/investment would still be used for other purposes.

On the other hand, productivity effects include: increased productivity arising from improvements to the existing infrastructure, increased interest from foreign investors, improved competitiveness of domestic goods and services in international markets, which in turn rises the demand for national exports, as found by Rose and Spiegel (2010).

A third category of effects, hard to quantify and whose existence is uncertain, include the so called "intangibles". The non-pecuniary "feel good" effect experienced by local citizens in terms of enhanced civic pride and national identity and the general excitement from the event experience is an instance of positive intangibles, which should be accounted for to estimate the full welfare impact. For example, Baade and Matheson (2016) find that the Olympic Games are perceived as a great international sporting event that brings increased utility to the population of the host country, arising from factors such as national-pride effects. While tangible benefits/costs can be measured in terms of the amount of income earned or expenditure incurred, intangibles do not possess an explicit monetary value (Coates, 2007).[3]

Regarding the temporal distribution of the various effects, Madden and Crowe (1998) identify three distinct phases. During the pre-event some domestic resources are diverted towards event-related activities (demand shift), like the construction and upgrading of venues, accommodation and transport infrastructure. This phase can lasts more or less periods, according to the type of event under consideration. For example, in the case of the Summer Olympic Games, it starts around five years before the year of the event, when the bidding process ends and the country is awarded with the hosting of the event. The second phase corresponds to the year of the event: the major flows of money are generated by the mega-event operations and international tourism. The last phase coincides with the post-event period, during which long-run socio-economic impacts may occur.

3. Simulating the economic effects of a mega-event with a CGE model

[3] Several studies have attempted to quantify the intangible benefits of the Olympic Games through the use of contingent valuation methodology, which constructs a set of survey questions that are designed to elicit the monetary value people place on whether certain events occur or do not occur (see e.g., Atkinson et al., 2008; Walton et al., 2008). Among possible immaterial costs generated by the mega-event, Andersson et al. (2008) identify environmental and social costs, like the degradation of natural fauna, noise pollution and congestion during the event.

CGE models are particularly suited to run “what-if” scenario simulations, to anticipate how the economy would look like if the policy change or shock had occurred. In the case of large event assessment, these simulations are intended to determine the effects into the hosting country of a change in expenditure and productivity on the endogenous variables of the model, by varying exogenous variables accordingly. Subsequently, the CGE model is re-solved to find new solution values for all of the endogenous variables. The new values represent a new equilibrium in which the supply and the demand balance in all markets at some new set of prices. The difference in the values of the endogenous variables in the baseline and the simulation represents the effect of the new expenditure and increase in productivity or, more generally, policy change.

In this respect, the mere choice of CGE modeling will not necessarily ensure a proper evaluation of the economic effects of a mega event. Assumptions under which the model is run should be as close as possible to those of the economy under investigation and the CGE exercise has to be designed so that it properly simulates the impacts induced by a mega-event. For example, developing countries face different initial conditions than developed economies, requiring much larger investment on infrastructure and are likely endowed with more unused unskilled labor resources. Besides, there are several important simplifications pertaining to the setup of CGE models that limit the robustness and relevance of the analysis. For example, it would be difficult to model traffic congestion, noise or incorporate other localized externalities associated with the event. When it comes to evaluate welfare impacts, the level of aggregation of the model matters, and CGE model may be constrained in this regard. As a matter of fact, although general equilibrium models are, in many respects, superior to other assessment methods, they have their own limitations and it is not all ensured that many key impacts would be accounted for.

Some fundamental questions must therefore be tackled before undertaking any assessment exercise, in this and other contexts. For example, which changes in the model structure are needed to better describe the economy under investigation? Which exogenous parameters, for which sectors, should be perturbed and what is their economic interpretation? To what extent the size and the sign of the results are assumption-driven and affected by the model set up? Can a sensitivity analysis on parameters and assumptions help testing the robustness of the simulation results? Is there available data to realistically gauge the magnitude of the exogenous shocks?

Simulating a the effects of a large international event is, to a large extent, a demand-driven simulation exercise, where the expenditures of the economy are reshuffled and new money are injected into the local economy from international tourists inflows. In other words, a mega-event results in a variation in some components of demand not induced by changes in relative prices or income. Depending on the type of event, in the years foregoing the event, the needed investment and construction expenditures on new infrastructure and facilities can be funded either by resources coming from other components of domestic demand, for example through an increase in direct taxation of households, or from financial inflows. During the year of the event, households partially switch their preferences towards event-related activities, simultaneously reducing their spending on other activities (in the absence of any increase in their income). Still, this is a reshuffling a local expenditure, where the crowding-out mechanism is at work. More generally, a mega event implies a change in the patterns of consumption and investment with respect to their baseline structure. This exogenous structural modification is simply a demand shifting and can be captured in a CGE model through the adjustment of some demand shifting parameters. CGE models automatically handles many of the displacement effects that arise from changes is national spending.

A second important economic effect generated by a mega-event is the increase in the number of foreign incoming tourists in the hosting country, occurring during the event-year. International tourism spending generated by holding a mega-event is considered to be the main contribution and benefit to the host economy (Dwyer et al., 2005). To simulate such an impact, one should consider that: more income, earned abroad, is spent in the hosting country; the pattern of final consumption changes, with higher demand for hotels, restaurants, transports and other services. How could this combined effect be captured in a CGE model? As suggested by Roson and Sartori (2014), a possibility is varying upwards (from its baseline level) the net inflow of international income transfers, while simultaneously increasing the demand for goods and services typically consumed by tourists. Another possibility is introducing a new sector (tourism exported sector, producing tourism products and services) and a representative consumer (international tourists, demanding for tourism products and services) into the CGE model (Li, 2012).

A third relevant consequence consists in the intangible positive (and negative, too) short- and long-term effects, generated by the new good image gained by the host country. To the extent that these effects translate into higher perceived quality of domestic goods and services in international markets, a tangible impact is the increase in the demand for exports.

In this (and other) context, modeling assumptions that are key for the results in other demand-driven simulation exercises turn out to be critical for the assessment of mega-events as well. Therefore, when interpreting the impacts of a certain shock, it is important to be aware of the assumptions under which the model is run, and how this may influence the various outcomes. Before explaining how to practically simulate a mega-event shock, this issue deserves an in-depth discussion, to which the next section is devoted.

3.1. Modeling issues: model closure, endowment and factor mobility

The debate on the closing rules is at the heart of the CGE literature since the very beginning (see, e.g., Shoven and Whalley, 1984; Robinson, 1991). The closure refers to the choices of which variables the model endogenously determines and which are exogenously fixed. In that respect, a CGE model is very flexible. An example of a closure decision is either assuming that the wage is endogenously determine by labor market clearing, or assuming that the wage is exogenous. This implies that the way factor endowments are modeled does affect the model closure, and the two aspects are intertwined.

Modifying the closure of the model allows for perturbing the economy under different assumptions. The choices made on closing rules have no influence on the solution to the baseline, but may influence the results of other simulations in significant way. Horridge (2000) discusses a number of criteria that should guide the choice of the model's closure. The time horizon of the simulation is a first aspect to consider (e.g., short- versus long-term simulation).

The closure is associated with the period of time needed for economic variables to adjust to a new equilibrium, which in turn affects the way factor markets are modeled. For example, in a short-run simulation capital stock is held fixed, because it takes some time to install and cannot be varied. In a typical short-run closure, the real wage, technology, capital stock, private consumption, investment, and government consumption are exogenous, whereas the rate of return on capital, employment, trade balance and technology are set exogenous in a typical long-run closure.

A second criterion has to do with the appropriated assumptions for those variables that the model does not explain but are part of the circular flow of income and spending in the economy, so that the model must account for them. For example, standard CGE models rely on the identity savings equal investment. In a savings-driven model, the saving rate is exogenous and constant, so that as income varies, the quantity of saving changes as well. The aggregate value of investment then changes to accommodate the variation in the quantity of savings. Instead, an investment-driven closure assumes that investment spending is fixed, and the savings rate adjusts to accommodate that level of investment.

The same story holds for the government balance and the balance of trade, often referred to as macro-closure. The government balance closure describes whether government savings, that is the difference between government revenues and expenditure, are endogenous or exogenous, and whether government spending is fixed. If government spending is fixed exogenously and revenues depend on a variety of endogenous tax instruments, government savings are determined endogenously. In revenue-neutral government closure, spending and revenue are both fixed, while tax rates are endogenous. Another alternative closure is that government savings are a flexible residual while all tax rates are fixed, or government savings and direct tax rates are both fixed and government consumption is the adjusting variable. If the event is mainly financed through new taxes and the government balance is retained fixed at its initial equilibrium level, tax rates must be exogenously fixed and government spending are endogenously determined.

The balance of trade closure describes whether financial inflows are exogenous and the exchange rate is endogenous. An exogenous current account closure fixes the supply of foreign savings, that is the current account deficit or surplus, at its initial level and the exchange rate adjusts to maintain it. For example, by fixing the balance of trade one can prevent a trade deficit generated by a reduction in the level of national savings. On the other hand, with a floating exchange rate an increase in spending, as a result of additional visitors from abroad, will have an impact on the real exchange rate, pushing it up. This, in turn, will impact negatively on other export- and import-competing industries (Dwyer et al., 2003). If, after the shock, financial inflows were below the exogenous level, a depreciation of the real exchange rate would reduce (increase) spending on imports (exports), through a fall (increase) in import (export) quantities at fixed world prices. Exchange-rate movements may thus be important determinants of the net economic impacts of events, especially in small open economy. The alternative closure is a fixed exchange rate that makes the balance of trade account endogenous.[4]

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[4] In the CGE literature, a number of stylized macro-closures can be found. The saving-driven neoclassical closure is opposed to the investment-driven Johansen closure. The latter combines fixed financial inflows, fixed real investment, and fixed real government

Clearly, the appropriate choice between different closures depends on the context of the analysis and should reflect as closely as possible the features of the particular circumstance one needs to simulate. For example, Bohlmann and van Heerden (2008), who estimate the potential economic impact of the 2010 World Cup through a comparative static CGE model, adopt a modified version of the short-run closure described in Horridge (2000): capital stock, technological change, tax rates and investment are hold fixed, whereas household consumption, employment level and the trade balance are endogenously computed. This choice reflects the need to simulate the funding of construction expenditure through higher taxes, the increased activity in building new stadiums and improving infrastructure in general, as well as the induced greater productivity and technological progress.

In Giesecke and Madden (2011) the baseline and counterfactual scenarios are simulated under different closures, to uncover the variation of certain unobservable variables during the period of hosting the mega-event and clarify the extent to which observed changes are attributable to the mega-event. The deviation resulting from the baseline gives the effect of hosting the mega-event under investigation.

Factor Endowments

One of the major effect generated by a mega-event is a temporary demand shock. The extent to which this additional demand competes for the utilization of scarce primary resources against alternative activities depends on how factors endowments are handled in the CGE model. The typical hypothesis in CGEs is that production factors (e.g., labor and capital) are supplied in fixed amount, exogenously given. If the release of local resources become important determinants of the overall economic outcome, excluding the possibility of employing unused local resources may underestimate the positive short-run impact generated by a (mega-event) demand shock, to the extent that the stock of primary resources is assumed fixed. A change in factor endowments can indeed be a significant shock perturbing an economy, because it changes its productive capacity. Furthermore, an increase in the supply of a factor causes its price to fall (unless demand for the factor is perfectly elastic) and affect the demand for and prices of other factors of productions, with resulting distributional effects.

A good example can be found in the labor market, in the presence of involuntary unemployment: an expansion of demand may activate unused labor resources and therefore generate real income growth. To capture this aspect in a CGE model, some specific labor supply functions must be introduced. Indeed, the standard three equations describing the labor (and other factors) market – the supply, demand and the market clearing condition – determine the supply, demand and the market clearing price (i.e., the wage rate), but cannot determine the unemployment rate. A wage curve, representing an inverse relationship between real wage rate and unemployment rate, is the additional equation the model needs to determine the

consumption. This closure may be preferable for simulations that explore the equilibrium welfare changes of alternative policies in a single-period simulation, because it avoids the misleading welfare effects that appear when financial inflows and real investment change (i.e., increases in financial inflows and decreases in investment raise household welfare, without capturing welfare losses in later periods that arise from a larger foreign debt and a smaller capital stock). See Lofgren et al. (2002) and Burfisher (2011) for an in-depth discussion.

unemployment rate endogenously. A CGE model can incorporate different views of how the labor market works and also illustrate the sensitivity of results to the different assumptions (Dwyer et al. 2000; for an exhaustive review on this topic, see Boeters and Savard, 2011).

Yet, a simple way to depict unemployment, without introducing a wage curve, can be by changing the factor market closure. With a full employment model closure, a shock to an economy causes wages and rents to adjust until the fixed supply of each factor is again fully employed. In a model with an unemployment closure in the labor market, a demand shock can lead to a change in the factor supply, that is the size of the labor force will adjust until factor supply and demand are again equal at either the initial wage rate (if fixed) or another level (if a wage curve is introduced). In the context of mega-event impact assessment, Madden (2006) shows that the degree of slackness in the labor market has a large influence on the results of CGE simulations, so that labor market closure rules do matter. This is confirmed by other studies (Roson, 1999; Bontout and Jean, 1998; Pant and Warr, 2016), which carry out some experiments in a model that allows for factor unemployment or alternative specifications of the labor market, resulting in considerable changes in industrial output and real GDP of the country.

In principle, the effective factor endowment can also be changed either through a variation in total factor productivity or when the factor moves from less to more productive sectors. In this case, the actual amount of factor does not change; it is the output per factor that varies. Separating the impacts of increases in factor endowments from other impacts arising from factor reallocation is important when interpreting results.

Factor mobility

As for factors endowment, in CGE models usually there are strong assumptions about factor mobility across the different production activities within a country. For example, labor is either perfectly mobile between sectors or sector-specific. With perfect mobility of labor, simulations lead to reallocation of labor among different sectors of the economy and result in a homogenous market and equalized wages across sectors. A practical implication of the factor mobility assumption is that it influences the slope of industry supply curves. All else equal, the more mobile the factors are, the flatter the supply curve is and the larger the supply response to any type of economic shock.

In the real world, however, there may be substantial variations between wage rates of different skill classes and among sectors, partially due to the different levels of productivity. Furthermore, the empirical literature on costs of factor reallocation highlights the existence of severe costs of reallocation, mainly caused by non-transferability of skills and losses in skills, which hinders the mobility between sectors (Figura and Wascher, 2010). For example, to model imperfect inter-sectoral reallocation of labor within a CGE model, one possibility is introducing a migration function governing the movement of labor between sectors (McDonald and Thierfelder, 2009; Flaig et al., 2013). Migration would depend on the change in the relative wage, and the responsiveness of migration to wage changes is determined by a migration elasticity parameter.

The degree of factors mobility matters in relation to the time horizon of the simulation exercise. This aspect is particularly relevant when the impact of a mega-event is simulated by means a *static* CGE model which distinguishes several simulation phases, as done in this study, differing -also- in the duration of the simulated shocks. While some factors (e.g., capital) are immobile in the short-run, they turn to be partially or fully mobile in the long-run, varying the economy's production response. Indeed, if the adjustment period is long enough, existing stocks of capital and labor can be replaced, and workers can move among industries in response to changes in wages and rents.

3.2. Simulation phases

The sign and the magnitude of the economic impacts generated by a mega-event are not only determined by the nature and size of the direct expenditure and productivity increases, but depend also on the type of mega-event hosted and the features of the economic context. Despite being very intense, though also very localized, the various effects can materialize over a varying time period, depending on the type of event one needs to simulat. For some large event, like the Olympic Games, this would suggest the use of a dynamic or inter-temporal CGE model, as opposed to static models, which can trace the adjustment time-path of the endogenous variables from the initial equilibrium to the new one, on a year-on-year basis. It is worth noting, however, that fully dynamic CGE models are computationally burdensome and can only be simulated with a sufficient degree of data aggregation.

In this context, an intermediate modeling solution that can balance the need to keep the model simple and the need to understand if and how long the mega event boosts economic growth is suggested, as possible reference for future studies. A standard static CGE model, briefly described in the next Section, is run one phase at a time; in each simulation round, the model is shocked to account for the phase-specific effects, under the model closure that best mimics the characteristics of the economy. The schematic representation provided in Table 1 is subsequently discussed.

Table 1. Modeling phases for a CGE mega-event simulation exercise.

Phase	**Shock(s)**	**Model closure/assumptions**	**Expected outcome**
Pre-event	- expansion of the demand for investment in event-related industries (construction, transport, communication, hotels, recreational services, etc.) - increase in financial inflows (if investment are financed with foreign money) - increase in household savings (if investment are financed with national money)	- flexible government and trade balance - sufficient degree of slackness in the labor market to accommodate the possible increase in the demand for labor - sufficient degree of factor mobility	- structural change in the patterns of consumption and investment - demand for consumption decreased is the event is funded with increased savings - GDP growth to the extent that unused labor resources are employed - increased competitiveness in international markets due to lower domestic prices - Dutch disease (lower competitiveness of the other industries)
Event-year	- new money from international tourists expenditure on event activities (increase in international transfers) - reshuffling of household spending toward event-activities; total household consumption can increase - displacement effects on household consumption - increase in the stock of capital	- flexible government and trade balance - sufficient degree of slackness in the labor market to accommodate the possible increase in the demand for labor - sufficient degree of factor mobility	- expansion of tourist-related industries - increase in the marginal productivity of labor induced by capital stock increase - positive effect on national income due to new capital stock (and unused labor resources, if any) - pressure on domestic prices - increase in government revenues from higher national income
Post-event	- increase in the demand of exports, not induced by changes in relative prices or income - interests on foreign and national debt to repay through government and trade surplus - same increase in the stock capital from the previous phase - intangibles (benefits/costs without monetary value)	- fixed government and trade balance surplus - full employment - full factor mobility	- positive effect on national income due to new capital stock - reduction in government expenditure or increase in tax revenues (depending on how interests are paid)

Pre-event simulation

The major economic shock of the pre-event phase consists in the changes occurring in the investment patterns with respect to their baseline structure, in the event-related industries, like construction, transport, hotels and recreational services. Clearly, new investment expenditures need to be funded. These financial resources may come either from financial inflows (i.e., international transfers) attracted by future earnings, or from national savings; in the latter case, the household marginal propensity to save increases, and consumption is reduced by the same proportion. Flexible government balance and trade balance are therefore necessary.

The expansion of the mega-event industries comes at the expense of other sectors in the economy (the Dutch disease previously mentioned). The whole productive structure of the country changes, with possible consequences in terms of income and wealth distribution. To the extent that unused labor resources are employed to meet additional demand for labor a positive effect on national income is expected. For this reason, the possibility of a certain degree of slackness in the labor markets has to be included in the model set up.

Event-year simulation

The two major economic effects of the event-year are: national households partially switch their preferences towards event-related activities, and the number of foreign incoming tourists in the hosting country increases. On the one hand, the pattern of final consumption changes, with higher demand for services (e.g., hotels, restaurants, transports); on the other hand, more income, earned abroad, is spent in the hosting country.

Displacement effects are also at play. Potential visitors may respond to higher prices of local services (e.g., restaurants, transport, hotels) by going elsewhere. Local residents may leave the area for the duration of the event. These effects are automatically incorporated into CGE models. The marginal propensity to save is set at its baseline or lower level, as total household consumption might increase: national consumers may decide to partially postpone their savings to the next periods, to enjoy and benefit from the occasional event). Changes in the patterns of expenditure brought about by the event give also rise to increases and decreases in tax revenues from different sectors.

The additional demand generated by foreign tourists and local visitors will create pressure on prices, as the stock of domestic primary resources cannot be readily adjusted in the short run. In other words, increased tourism demand raises the production costs and therefore the market prices of the domestic products. Since domestic goods become relatively more expensive than domestic products, consumers and firms will substitute domestic goods with imports.

Any increase in the demand for labor is met by an increase in employment, with little or no effect on wage rates. This assumption is reasonable, because the short period involved would seem insufficient for the labor market to generate a general wage rise in response to the increased demand for labor. The investment made in the previous phase become new capital stock: the total national income rises, as well as the relative marginal productivity of the other factors of the economy

Post-event simulation

The good image gained by the host country translates into an improved competitiveness of domestic goods and services in international markets. The country's demand for exports increases without any price change. The capital stock is retained at level of the event-year phase, retaining the positive effects on national income.

The interests on the financial resources employed to fund the investment in the pre-event phase need to be paid. For this reason, a fixed government and trade surplus are assumed.

4. An illustrative CGE simulation exercise

The model developed for this study is a static single country computable general equilibrium model, with a standard theoretical structure. The economy is disaggregated into ten industries (non mega-event industries: agriculture, processed food, energy intensive, manufacture; and mega-event industries: construction, trade, transport, communication, recreations and services), two primary factors (labor and capital), a representative household, a public and a foreign sector. The structural parameters of the model are estimated assuming that the economy is in equilibrium in the calibration period. Non-calibrated parameters include the elasticities of substitution, some of them have been taken from the GTAP model (Hertel, 1997). An illustrative Social Accounting Matrix (SAM) mimics the Italian SAM at the year 2011 (GTAP9 dataset, see Aguiar et al., 2016).[5]

In short, economic agents are price-takers operating in a competitive market. Consumers choose goods according to their preferences and relative prices, but are constrained by their amount of disposable income. Utility maximization is based on preferences represented by a Stone-Geary utility function (a linear expenditure system function).

A representative firm in each industry adopts a constant return to scale technology and operates under perfect competition. Firms maximize their profits and face a nested production function, with capital, labor and intermediate inputs as factors of production. At the first level, there is a Leontief technology with value added and intermediate inputs as composite factors of production, while at the second level value added is a constant returns to scale CES technology with labor and capital as factors of production. Intermediate inputs are aggregated by a Leontief technology. Total factor endowments (capital and labor) are fixed at the national level and fully mobile between the ten industries of the economy, allocated on the basis of equality between real wage and marginal productivity in each industry.

The distribution of domestically produced commodities among domestic demand and exports is governed by relative prices on these markets, using constant elasticity of transformation (CET) functions, which reflects imperfect product transformation. The composite aggregates of domestic and imported commodities exhibit constant elasticity of substitution (CES), following Armington (1969), where the relative price determines the optimal mix of consumption between domestic and imported good. The small-country assumption adopted in this model implies that world market prices for imports and exports are both fixed, the trade balance is exogenous, whereas the exchange rate is allowed to vary. Government balance is fixed at its initial level, revenues come from direct taxes on factor incomes and total output.

4.1. Simulation results

[5] Since the model structure is very standard, equations are not presented. The model code is a .gms (GAMS) file, available upon request.

To do

Pre-event simulation

Event-year simulation

Post-event simulation

4.2. Sensitivity analysis

5. Conclusions

To do

References

Aguiar, A., Narayanan, B., and R. McDougall. 2016. "An Overview of the GTAP 9 Data Base". *Journal of Global Economic Analysis*, 1(1): 181-208. doi: 10.21642/JGEA.010103AF.

Allan, G.J., Lecca, P., and Swales K. 2017. "The impact of temporary but anticipated tourism spending: An application to the Glasgow 2014 Commonwealth Games", *Tourism Management*, 59: 325-337.

Andersson, T.D., Armbrecht, J. and Lundberg, E. 2008. "Impact of Mega-Events on the Economy", *Asian Business & Management*, 7: 163-179.

Armington, P. 1969. *A theory of demand for products distinguished by place of production*. International Monetary Fund Staff Papers, XVI (1969), 159-78.

Atkinson, G., Mourato, S., Szymanski, S. and Ozdemiroglu, E. 2008. "Are We Willing to Pay Enough to ''Back The Bid''?: Valuing the Intangible Impacts of London's Bid to Host the 2012 Summer Olympic Games", *Urban Studies*, 45: 419-444.

Baade, R., and Matheson, V. 2016. "Going for the Gold: the Economics of the Olympics" *Journal of Economic Perspective*, 30(2): 201-218.

Blake, A. 2005. *The Economic Impact of the London 2012 Olympics*, Discussion Paper 2005⁄05, Christel DeHaan Tourism and Travel Research Institute, Nottingham University.

Bohlmann, H.R., and van Heerden, J.H. 2005. *The impact of Hosting a Major Sport Event on the South African Economy*, University of Pretoria, Department of Economics Working Paper Series, 2005-09.

Bohlmann, H.R., and van Heerden, J.H. 2008. "Predicting the economic impact of the 2010 FIFA World Cup on South Africa", *International Journal of Sport Management and Marketing*, 3(4): 383-396.

Bontout, Bon and Jean, Sebastien (1998), Wages and Unemployment: Trade-Off under Different Labour Market Paradigms, CEPII (Working Paper) Document de travail No. 98-13.

Burfisher, M.E. 2011. *Introduction to Computable General Equilibrium models*. Cambridge University Press.

Coates 2007

Crompton, J.L. 1995. "Economic Impact Analysis of Sports Facilities and Events: Eleven Sources of Misapplication", *Journal of Sports Management*, 9: 14–35.

Dwyer, L., P. Forsyth, J. Madden, and Spurr, R. 2000. "Economic Impacts of Inbound Tourism under Different Assumptions about the Macroeconomy", *Current Issues in Tourism*, 3(4): 325–63.

Dwyer, L., P. Forsyth, R. Spurr, and Ho, T. 2003. "The Contribution of Tourism to a State and National Economy: A Multi-Regional General Equilibrium Analysis", *Tourism Economics*, 9(4): 431–48.

Dwyer, L., Forsyth, P. and Spurr, R. 2004. "Evaluating tourism's economic effects: new and old approaches", *Tourism Management*, 25: 307–17.

Dwyer, L., Forsyth, P., and Spurr, R. 2005. "Estimating the Impacts of Special Events on an Economy," *Journal of Travel Research*, 43: 1-9.

Dwyer, L., Forsyth, P., and Spurr, R. 2006. "Assessing the Economic Impacts of Events: A Computable General Equilibrium Approach", *Journal of Travel Research*, 45: 59-66.

Dwyer, L., and Forsyth, P. 2009. "Public sector support for special events", *Eastern Economic Journal*, 35: 481–499.

Figura, A., and Wascher, W. 2010. "The Causes and Consequences of Sectoral Reallocation: Evidence from the Early Twenty-First Century", *Business Economics*, 45(1): 49-68.

Flaig, D., Grethe, H. and McDonald, S. 2013. *Imperfect labor mobility in a CGE model: does factor specific productivity matter?* Paper presented at the 16th Annual Conference on Global Economic Analysis, Shanghai, China, June 12-14, 2013. Available at https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4214.

Giesecke, J.A., and Madden, J.R. 2007. The Sydney Olympics, seven years on: an ex-post dynamic CGE assessment. CoPS General Paper No. G-168. Centre of Policy Studies, Monash University, Melbourne.

Giesecke, J.A., and Madden, J.R. 2011. "Modelling the economic impacts of the Sydney Olympics in retrospect e Game over for the bonanza story?", *Economic Papers*, 30: 119e287.

Hertel, T.W. (Ed.) 1997. *Global Trade Analysis: Modeling and Applications*. Cambridge University Press.

Horridge, M. 2000. *ORANI-G: a generic single-country computable general equilibrium model*, CoPS Working Paper OP-93, Centre of Policy Studies, Monash University.

Jago, L., Dwyer, L., 2006. *Economic Evaluation of Special Events: A Practitioners' Guide,* Common Ground Publishers, Altona, Australia.

Li, S.N. (2012) "A simple framework for evaluating the welfare impacts of a large event", *Tourism Analysis,* 17(4): 495-508

Li, S.N. and Jago, L. 2013. "Evaluating economic impacts of major sports events – a meta analysis of the key trends", *Current Issues in Tourism*, 16(6): 591-611. http://dx.doi.org/10.1080/13683500.2012.736482.

Li, S.N., Blake, A., Cooper, C., 2011. "Modelling the economic impact of international tourism on the Chinese economy: a CGE analysis of the Beijing 2008 Olympics", *Tourism Economics*, 17(2): 279-303.

Li, S., Blake, A., and Thomas, R. 2013. "Modelling the economic impact of sports events: The case of the Beijing Olympics", *Economic Modelling*, 30, 235e244.

Lofgren 2002.

Madden, J.R. and Crowe, M. 1998. "Estimating the Economic Impact of the Sydney Olympic Games". Mimeo. Available at https://www.researchgate.net/publication/23732594.

Madden, J.R. 2002. "The Economic Consequences of the Sydney Olympics: The CREA⁄Arthur Andersen Study", *Current Issues in Tourism*, 5: 7-21.

Madden, J.R. 2006. "Economic and fiscal impacts of mega events: a general equilibrium assessment", *Public Finance and Management*, 6(3): 346-394.

Matheson, V. 2009. "Economic Multiplayers and Mega-Event Analysis", *International Journal of Sport Finance*, 4: 63-70.

McDonald, S. and Thierfelder, K. 2009. STAGE_LAB: An Applied General Equilibrium Model with Enhanced Labour Markets. Mimeo.

Müller, M. 2015. "What makes an event a mega-event? Definitions and sizes". *Leisure Studies*, http://dx.doi.org/10.1080/02614367.2014.993333.

Pant, H.M. and Warr, P.G. 2016. "Modelling Involuntary Unemployment in Applied GE Models". Paper presented to the 19th Annual Conference on Global Economic Analysis, June 15-17, The World Bank, Washington DC. Available at https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=5091.

Robinson, S. 1991. "Macroeconomics, Fonancial variables, and Computable General Equilibrium Models", *World Development*, 19(11): 1509-1525.

Rose, A.K. and Spiegel, M.M. 2011. "The Olympic Effect", *The Economic Journal*, 121: 652-677.

Roson, R., and Sartori, M. 2014. "Climate Change, Tourism and Water Resources in the Mediterranean: a General Equilibrium Analysis", *International Journal of Climate Change Strategies and Management*, 6(2): 212-228.

Russo, B. (2009). Innovation and the long-run elasticity of total taxable income. Southern Economic Journal, 75(3), 798-828.

Saayman, M. and Rossouw, R. 2008. “The Economic Value of the 2010 Soccer World Cup”, *Acta Commercil*, 8(1): 1-14.

Shoven, J.B, and Whalley, J. 1984. “Applied General Equilibrium Models of Taxation and International Trade: An Introduction Survey”, *Journal of Economic Literature*, 22(3): 1007-1051.