Hosting a Mega-Event: Is it Good or Bad for the Economy? General Equilibrium Models as a Litmus Paper Test
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In this paper, we show that results are different because assumptions are different and because the range of effects considered is different, even when the same model is employed. Furthermore, some critical hypotheses are not often clearly stated. We advocate some kind of standardization in the process of model building for the economic assessment of mega-events. Only a transparent and replicable model exercise can serve as a “litmus paper”, to ascertain whether hosting a mega-event is good or bad for an economy.

Keywords
Computable general equilibrium modeling, methodological issues, mega-events economic impact assessment

JEL Codes
C68, Z28, Z38

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1. Introduction

“Six months after hosting the 2016 Summer Olympic Games, the Rio de Janeiro sport venues are already idle and in disrepair, raising questions about a legacy that organisers promised would benefit the Brazilian city and its residents.”
The Guardian, 2017

Would you like to get your country hosting the next Olympic Games? Should this question be asked some years ago, the likely answer would be: “Yes”. Indeed, hosting “mega-events”¹, such as the Olympics or the Expo, has long been regarded as an opportunity for economic growth, creating long-lasting benefits and attaining international recognition. For instance, the 1964 Tokyo Olympic Games became a hallmark of the economic recovery of Japan after World War II. Other positive examples may be Los Angeles 1984 and Barcelona 1992 (Preuss, 2004; Brunet, 1995; Zimbalist, 2015; The Guardian, 2002).

Recently, however, both the scientific community and the public opinion at large have turned much more skeptical about the impact of mega-events (e.g., Baade and Matheson, 2002, 2016; Horne, 2004; Pillary and Bass, 2008; Barclay, 2009; Zimbalist, 2015; The Guardian, 2012, 2017). It is now recognized that a mega-event may subtract financial resources to alternative projects, possibly providing higher social returns. Some studies find that a mega-event is rarely profitable (Coates and Humphreys, 2008; Baade and Matheson, 2016), as economic benefits hardly compensate for the substantial costs and risks incurred (Barclay, 2009).

According to Baade and Matheson (2004), following the 1994 soccer World Cup in the United States host cities experienced a net economic loss rather than the predicted gain. Giesecke and Madden (2011) show that Sydney 2000 generated a real consumption loss of $2.1 billion. The Athens 2004 Summer Olympic Games are regarded as one key factor behind the Greek debt crisis (The Guardian², 2012).

Host cities are often left with specialized infrastructure that has little use beyond the mega-event, so that they may face heavy long-term expenses for the maintenance of the so-called “white elephants” (Baade and Matheson, 2016). For example, many of the venues of Athens 2004 have fallen into disrepair and Brazilian’s Olympic infrastructure is experiencing the same. (The Guardian³, 2017).

So, are mega-events good or bad for the hosting economy? Why is it that some events appear successful and other disasters? Why the perception of impacts has changed over time? To answer these (and other) questions, there is a need to go beyond the simple narratives and “stylized facts”, to undertake some serious scientific investigation, based on verifiable data and testable models.

Yet, and despite the fact that most recent studies use the same modeling tool, namely some

¹Mega-events are defined 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” (Müller, 2015).
²“No one knows how much the Olympics cost Greece – although many think they played a major role in producing the debt that spurred the country’s economic downfall.”
³“The iconic stadium has fallen into a state of abandonment and has been closed to tourists due to a dispute between the stadium operators, the Rio state government, and Olympic organisers over $1m in unpaid electricity bills and management of the venue.”
Computable General Equilibrium (CGE) model, results are sometimes contradictory. One may say that these divergences may be 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 exhibit opposite findings, thereby hindering the trustiness of the economic analysis for policy guidance.

The simple point we want to make here is this: results are different because assumptions are different and because the range of effects considered is different, even when the same model is employed. Furthermore, some critical hypotheses are not often clearly stated. Indeed, there is no single way to make numerical simulations with a CGE model, which may differ in terms of shocks and/or closure rules.

The success of a recipe depends on the ingredients, which must be listed outside the package of any food product. Analogously, we advocate some kind of standardization in the process of model building for the economic assessment of mega-events. Only a transparent and replicable model exercise can serve as a “litmus paper”, to ascertain whether hosting a mega-event is good or bad for an economy (and why, how much, etc.).

To this end, after reviewing the literature (Section 2), we discuss in Section 3 of this paper the key effects at play and (Section 4) how they can be simulated in a CGE setting. In Section 5, we present an illustrative model and simulation exercises, based on the proposed reference framework. A final section draws some conclusions.

2. CGE modeling of mega-events

The traditional approach for the impact assessment of large-scale investments is the Input-Output analysis (e.g., Lee and Taylor, 2005). Recently, I-O models have been progressively replaced by Computable General Equilibrium (CGE) models, in all those contexts (including the assessment of mega-events) where changes in relative prices and in the structure of the economic system matter. Indeed, after the pioneering contribution by Madden and Crowe (1998), the number of studies using CGE models for the economic analysis of mega-events has been steadily increasing.

More generally, CGE models have become a standard tool of empirical economic analysis and policy assessment. They are extensively employed in many fields, most notably to assess international trade, fiscal and environmental policies, but their adoption for the assessment of mega-events is relatively recent.

The discussion on the drawbacks of I-O analysis dates back to Crompton (1995), who identified few typical problems in I-O 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 by the I-O approach 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 I-O 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 I-O models is infinitely elastic supply curves. As such, I-O 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 by construction (Dwyer et al., 2004; 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). Dwyer et al. (2005) estimate the economic impact of a major sport event (a car race) at the national level, using both a standard I-O analysis and a CGE model. They find that net aggregate benefits computed with the standard I-O model are about two times larger than those estimated with the general equilibrium model.

CGE models build upon the Walrasian theory of general equilibrium and on the key concepts of market clearing and optimizing behavior of rational economic agents. A CGE model traces the circular flow of income and represent 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. From a mathematical viewpoint, a CGE is a large non-linear system, to be solved with appropriate mathematical algorithms, and with parameters calibrated on real world data. Counterfactual simulations are typically carried out by changing exogenous parameters in a comparative static setting.

Since the contribution of Madden and Crowe (1998) on the economic impact of the Sydney 2000 Summer 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 cases. Some other studies only provide partial analyses, as some economic effects are not fully taken into account (Li et al. 2011; Li et al., 2013; Allan et al., 2017). Contrary to I-O models, most CGE models assume full employment of available resources, thereby ruling out the employment of unused primary factors (Giesecke and Madden, 2007, 2011). As noted by Madden (2006), the way in which labor market is modeled has an especially large influence on the results of a CGE simulation.

The study by Blake (2005) on the London 2012 Olympics shows that the impact of the Games

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4CGE analysis is also considered superior to other evaluation methods, like cost-benefit analysis (CBA). 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 benefit- and cost-side of a CBA, especially regarding the quantification of non-economic elements. Finally, macro-econometric modeling cannot capture the interrelationships of different industries in an economy (Russo, 2009).

5This does not imply that in CGE models primary resources (i.e., labor, capital) are always fully employed or that trade deficit/surplus are not allowed. This issue will be further discussed in Section 4.
may vary considerably 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 differential sectoral impact is an example of the so-called “the Dutch disease”: higher competitiveness in some industries causes lower competitiveness elsewhere in the economy.\(^6\)

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 Australia’s eight states and territories, and identify three routes of direct effect on the economies of New South Wales (where Sydney is located) and Australia: (i) construction of the Games facilities and associated financing, financed via direct taxation of New South Wales 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-year and post-event). 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 some major determinants of the size and sign of the overall economic 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, two studies on the economic impact of Beijing 2008 Olympics arrive at qualitatively different results (Li et al., 2011; Li et al., 2013).

The extent to which differences in results are due to model assumptions is investigated in Li et al. (2013) and Allan et al. (2017). Li et al. (2013) assume that firms compete in a Dixit–Stiglitz 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 effects of the Glasgow 2014 Commonwealth Games, finding that results are very sensitive to the degree to which economic agents are forward-looking and on the timing of pre-announcement of the event.

Bohlmann and van Heerden (2005, 2008) and Saayman and Rossouw (2008) consider the 2010 Soccer World Cup in South Africa, and its various impacts (i.e., infrastructures development, increased tourism and financing implications), recognizing that the simulation results of the shocks applied to the economy depend to a large extent on the model closure.

To sum up, the key insight emerging from a review of the literature is that model results can be substantially different, despite the use of a common modeling approach (CGE), because of the nature of the exogenous shocks considered and of the (sometimes hidden) assumptions and

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\(^6\) The Dutch disease (Corden and Neary, 1982) refers to the apparent relationship between the increase in exploitation of natural resources and a decline in the manufacturing sector. An increase in revenues from natural resources (or inflows of foreign aid) will make a given nation’s currency stronger compared to that of other nations, resulting in the nation’s other exports becoming more expensive for other countries to buy, making the manufacturing sector less competitive. While it most often refers to natural resource discovery, it can also refer to any development that results in a large inflow of foreign currency, like an increase in tourism receipts.
closure rules. In the rest of the paper, we shall try to discuss how, why and how much the various “ingredients” of the “model recipe” may affect the simulations output.

3. Economic processes triggered by a mega-event
Mega-events are atypical tourism activities where the scale of investment in bid development, complexity of decision making involved and the potential impacts are great and lasting (Li and McCabe, 2013). As pointed out by Faulkner (1993), “holding large scale events implies a range of economic, social, cultural, political and environmental impacts”. These features make a mega-event somewhat different from other short run Keynesian demand-pushing expenditure, like the construction of new transport infrastructures.

Consider first the multiplicity of effects generated by a mega-event and the time when they occur. Two main categories of effects can be identified: expenditure effects and productivity effects.

Examples of expenditure effects are: investments to build event-related venues and facilities (e.g., sport buildings in the case of sport events, other temporary facilities) and renovation of infrastructure (e.g., transportation, information technology); operational expenditures (e.g., ceremonies and programs, media and press center, security, administration and event promotion); tourist inflows accompanied by increased expenditure. Funding of expenditure and investment can be based on foreign, domestic private and domestic public sources. This distinction is important when it comes to accurately estimate 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 between 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.

The productivity effects include: increased productivity because of improved infrastructure, higher competitiveness of domestic goods and services in international markets, rising export demand (Rose and Spiegel, 2010).

Productivity effects are related the so-called “intangibles” (Atkinson et al., 2008). For instance, Baade and Matheson (2016) stress that Olympic Games are perceived as a great international sporting event that brings increased utility to the population of the host country, arising from non tangible factors like “national pride”. 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; degradation of natural fauna, noise pollution and congestion are examples of negative intangibles. Both should be accounted for in the estimation of the overall welfare impact (Li and McCabe, 2013). Giesecke and Madden (2011) indeed find that the Sydney Olympic Games had a beneficial effect on the Australian economy only if intangible benefits were considered to be large enough. However, while tangible benefits/costs can be measured in terms of the amount of income earned or expenditure incurred, intangibles are hard to quantify, as they do not possess an explicit monetary value. 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 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).

Figure 1 summarizes the main economic effects generated by a mega-event.

![Economic Effects Diagram]

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

Regarding the temporal distribution of the various effects, Madden and Crowe (1998) identify three distinct phases. During the pre-event phase some domestic resources are diverted towards event-related activities (a demand shift), like the construction and upgrading of venues, accommodation and transport infrastructures. This phase has a variable duration, depending on the type of event under consideration. For example, in the case of the Summer Olympic Games, it could start around five years before the year of the event, at the time when the country is awarded with the hosting of the event and the construction activities begin.

The second phase corresponds to the period when the event occurs. This is the time of expenses for operations and international tourism. The last phase is the post-event period, during which the socio-economic legacy (if any) becomes apparent. For Li and McCabe (2013) legacy includes “tangible and intangible elements of large-scale events left to future generations of a host country where these elements influence the economic, physical and psychological well-being at both community and individual levels in the long-term”.

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

CGE models are particularly suited to run “what-if” scenario simulations, to depict how an economy would look like if a policy had been implemented or a shock had been occurred. In the case of a large event assessment, these simulations are intended to gauge the effects in the hosting country of a change in expenditure and/or productivity. Not all impacts can be easily captured within a CGE framework, though. For example, it would be difficult to model traffic congestion, noise or to incorporate other localized externalities associated with the event. When it comes to evaluate some impacts on welfare, the level of aggregation of the model matters. Depending on the nature of the mega-event taken into consideration, economic effects may be
very limited in time and quite localized, often restricted to a specific city or region. Proper model design is necessary to get meaningful and informative simulation exercises. Some key questions are: 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? Are there available data to realistically gauge the magnitude of the exogenous shocks? These are what we refer here as “ingredients of the model recipe”. A mega-event induces a change in the patterns of consumption and investment. This structural modification can be captured in a CGE model through the adjustment of some demand shifting parameters. Another expenditure effect is due to the increase in the number of tourists in the hosting country, occurring during the event. Extra international tourism spending is often regarded as the main advantage 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. Roson and Sartori (2014) suggest to model this effect by increasing the net inflow of international income transfers, while simultaneously augmenting 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 possibly more representative consumers (international tourists, demanding for tourism products and services) (Li, 2012).

Intangible effects related to the national identity and “brand” can also be quite relevant. To the extent that these effects translate into higher perceived quality of domestic goods and services abroad, a tangible impact is the increase in the export demand. Also, a better image may result in a higher inflow of international tourists, lasting after the event is concluded.

It is essential that a CGE model is designed so as to capture the relevant characteristics of the economy and to capture most of the effects coming into play when the realization of a mega event is simulated. This is a somewhat more technical issue, to which the next section is devoted.

4.1. Modeling issues: closure rules and working assumptions

A closure in a CGE model refers to the partition between endogenous and exogenous variables in the system. An example of a closure rule is the endogenous wage determination through labor market clearing, which is alternative to fixing real or nominal wages. Other instances are the determination of the public sector or trade balances. Not surprisingly, the debate on the appropriate closing rules to be chosen in the various circumstances has been at the heart of the CGE literature since its very beginning (see, e.g., Shoven and Whalley, 1984; Robinson, 1991). Closing rules may influence the results of numerical simulations in a 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). Some economic variables, like the capital stock, need time to adjust to a new equilibrium, affecting the way factor markets should be modeled. The time dimension is also important when modeling the impacts of a mega-event, because the many effects do not occur simultaneously. During the
pre-event phase, the expansion of demand for investment and the increase in financial inflows usually calls for a model closure with flexible government and trade balances, as well as with some degree of slackness in the labor market. Instead, these assumptions may not be justified when modeling the post-event phase, where, for example, a trade surplus may be necessary to repay the interests burden on the cumulated foreign debt.

A second criterion has to do with the appropriate assumptions regarding the circular flow of income and spending in the economy. For instance, many CGE models impose the equality of savings and investments (as it would be the case in a closed economy). When the saving rate is given, total savings and investments are endogenously and simultaneously determined. In a different context (e.g., during the pre-event phase), it may be more appropriate to set investment spending, possibly making the savings rate endogenous.

The same holds for the government balance and the balance of trade, often referred to as macro-closure. The government balance closure defines 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 (possibly negative) are determined endogenously. In the case of a revenue-neutral government closure, spending and revenue are both fixed, while tax rates must be, of course, endogenous. In another alternative closure 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. Clearly, this closure rule is a critical aspect to be carefully assessed when simulating a mega-event. If the event is mainly financed through new taxes and the government balance is retained fixed at its initial equilibrium level, then tax rates should be exogenously fixed and government spending endogenously adjusts to maintain the fixed balance.

The assumptions on the balance of trade closure are also very important. This closure defines whether financial net inflows (identically equivalent to the foreign trade deficit) are exogenous and the exchange rate is endogenous, or vice versa. An exogenous current account closure fixes the supply of foreign savings, that is the current account deficit or surplus, at its initial level and lets the exchange rate adjust to maintain that level. In this case, an increase in real national income will push up the real exchange rate, with possible negative consequences on the relative competitiveness for some industries. Exchange rate movements may be important determinants of the economic impacts of large events, especially in small open economies. The alternative closure is a fixed exchange rate that makes the balance of trade account endogenous. This closure appears to be appropriate when the initial phase of a mega-event is simulated, because funding resources at this stage may come abroad, at least in part.7

Clearly, the choice about the closure rules depends on the purpose of the modeling exercise. Bohlmann and van Heerden (2008), who study the 2010 Soccer World Cup by means of a comparative static CGE model, adopt a modified version of the closure described in Horridge (2000): capital stock, technological structure, tax rates and investment levels are hold fixed, whereas household consumption, employment level and the trade balance are endogenously

7 In the CGE literature, a number of macro-closures are discussed. See, e.g., Lofgren et al. (2002) and Burfisher (2011).
obtained. This is due to the need to simulate the funding process through higher taxes, the
building of new stadiums and other infrastructure, and higher productivity. In Giesecke and
Madden (2011), baseline and counterfactual scenarios are simulated under different closures, to
uncover the contribution of a mega-event in the variation of some macroeconomic variables.
Many effects generated by a mega-event are a consequence of a change in the level and
structure of the final demand, including private and public consumption, as well as investment.
The extent to which this change in demand induces a different utilization of scarce primary
resources depends on how factors endowments/supply are handled in the CGE model. The
standard assumption is that primary resources (e.g., labor and capital) are supplied in fixed
amount. However, excluding the possibility of employing unused local resources may severely
underestimate some positive impact generated by a mega-event. In this respect, the hypotheses
underlying CGE and I-O models are totally opposite, and are at the basis of the large
discrepancies in the results obtained with these two classes of models.
This phenomenon is especially evident in the labor market. An expansion of demand may
activate unused labor resources (unemployment) and therefore generate real income growth,
which could be the case before and during the realization of a mega-event. To model this
process in a CGE setting, some labor supply functions could be introduced. For instance, a wage
curve, that is a relationship between real wage and unemployment rate, is the additional
equation a model needs to determine the unemployment rate endogenously (the difference
between total labor supply and equilibrium employment). Boeters and Savard (2011) illustrate
the many different ways in which the labor market can be modeled within a CGE model, and
Dwyer et al. (2000) discuss the sensitivity of results to the different assumptions. Madden (2006)
shows that the degree of slackness in the labor market has a large influence on the results of
CGE simulations dealing with mega-events, confirming the findings of other studies (Roson,
1999; Bontout and Jean, 1998; Pant and Warr, 2016), where CGE models have been used in other
contexts.
The effective endowment of production factors can also change through a variation in factor
productivity, which modifies the output per factor. Or when production factors move from less
to more productive sectors: factor reallocation can indeed affect the system productivity. To the
extent that a factor is allocated more efficiently, this results in higher productivity. Iregui (2003)
shows that the elimination of global restrictions on the mobility of labor generates efficiency
gains that could be of considerable magnitude. However, any increase in an element of final
demand triggers many economic processes besides factor reallocation, and the final impact on
the systemic productivity is not necessarily positive. Furthermore, the empirical literature
highlights the existence of severe costs of factor reallocation, mainly caused by non-
transferability and losses in skills, which hinders the mobility between sectors (Figura and
Wascher, 2010).
As for factors endowment, CGE models do need to make assumptions about factors mobility
across the different production activities within a country. To the best of our knowledge, CGE
studies on mega-events do not discuss the implications of different factor mobility hypotheses,
unlike other research fields where CGE models have been extensively employed (i.e.,
international economics, development economics; see e.g. De Melo, 1977; Kilkenny and
One standard assumption is that both labor and capital are perfectly mobile between sectors and allocated such that wages and rents are equalized across sectors. The assumption of a single homogenous factor market may, however, overestimate the economic impact of an increase in an element of the final demand. The degree of factor mobility across sectors does affect the economy’s production response to a demand change, through 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. If hosting a mega-event pushes up the demand for investment, the impact on total production will be larger under perfect factors mobility assumption.

In presence of barriers to inward factors mobility (e.g., factor reallocation costs) or segmented factors market, different levels marginal productivity imply different wages and rents among sectors in equilibrium (Flaig et al., 2013). In this case, inter-sectoral factor reallocation must be governed explicitly in the model. One possibility is introducing a migration function governing the movement of the factor between sectors (McDonald and Thierfelder, 2009). Migration would depend on the change in the relative price of the factor across sector, and the responsiveness of migration to price changes is determined by a migration elasticity parameter. For example, Deepak, West, and Spreen (2001) define two types of labor, high- and low-skilled labor, with different migration propensities. The introduction of a segmented labor market requires, however, assembling a proper dataset, with information about the sectoral employment of the various types of labor considered and the substitution elasticities.

The degree of factors mobility also matters in relation to the time horizon of the simulation exercise. While full factor mobility is a reasonable assumption in case of long-run simulations, short-run simulations would be better carried out under the hypothesis of imperfect factor mobility, at least for those production factors which are typically partially mobile (e.g., capital). Hosting a mega-event generates both short- and long-run effects, which take place in different phases (Madden and Crowe, 1998). As consequence, simulating the long-run impact of productivity effects would require different factor mobility assumptions then simulating the short-run impact of a change in consumption patterns.

4.2. Simulation phases: the phase-static CGE modeling solution

The sign and magnitude of the economic impacts generated by a mega-event are determined by the nature of the event, its context and timing. To illustrate the modeling issues associated with the various mechanisms at work, we can distinguish three phases, which may be analyzed by means of a relatively simple CGE setting, in a set of comparative statics simulations. In the following, we briefly discuss what kind of processes is considered in each phase, and how they could be simulated into the model. The types of shock, the closure rules adopted and the expected outcomes are summarized in Table 1.

4.2.1. Pre-event phase

This phase is characterized by the construction of facilities and infrastructure for the event. A key aspect, determining the overall impact on the economic system, is how the investment plan is funded. Financial resources may either come from abroad (i.e., international investments or
transfers), or internally, through additional savings or taxes, both reducing consumption levels. In our simulations pertaining to this phase, government and trade balances are endogenous, whereas the exchange rate and the baseline government spending are held exogenous. The extra demand for public and private investment generates a pressure on available resources, pushing up production costs of domestic goods as well as their market prices. Consumers and firms substitute some domestic goods with imports, getting relatively cheaper. The trade balance deteriorates which, from a financial perspective, amounts to an inflow of foreign financial capital.

When more resources are employed in the event-related sectors of the economy, they are partially drawn away from productive activities elsewhere in the economy (the “crowding out” effect). As the relative prices of all inputs change, other activities are discouraged. The net effect on the overall economic welfare and national income is therefore uncertain and may well be negative, even in the presence of unemployment.

4.2.2. Event phase
During the realization of the event, consumption patterns change with an expansion of event-related goods and services. Total consumption levels may also increase, with a corresponding decline in savings. Also, an inflow of international tourists may take place, thereby boosting the demand for some consumption items. Some displacement effects may come into play as well: potential visitors and local residents could respond to higher prices of local services by either going elsewhere or leaving the area for the duration of the event.

New infrastructure and capital stock is now available, since the pre-event construction phase is completed: marginal productivity of labor and other factors gets higher. If labor (or other primary resource) is not fully employed, then the economy can expand.

4.2.3. Post-event phase
The good image, possibly gained by the host country, could translate into improved competitiveness of (some) domestic goods and services in international markets. Quality-adjusted productivity rises, positively affecting domestic output, final demand and national income. This effect overlaps with the one already observed during the realization of the event, linked to the higher stock of capital infrastructure.

After the event, some interest services on the foreign debt may have to be paid back. This may require a surplus in the government and trade balances.
Table 1. Modeling phases to simulate a mega-event by means a static CGE model.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Main shock(s)</th>
<th>Closure</th>
<th>Expected outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-event</td>
<td>- expansion of the demand for investment expenditure in event-related industries</td>
<td>- flexible government and trade balance to allow for mega-event financing</td>
<td>- increase in the financial inflows and appreciation of the real exchange rate (trade deficit)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- sufficient degree of slackness in the labor market</td>
<td>- increase of household savings and decreased demand for household consumption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- full factor mobility</td>
<td>- structural change in the patterns of final demand (crowding out effects)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- loss of competitiveness in international markets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- lower competitiveness of non-related event industries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- uncertain effect on GDP</td>
</tr>
<tr>
<td>Event</td>
<td>- new money from international tourists expenditure on event activities (increase in international transfers)</td>
<td>- flexible government and trade balance</td>
<td>- expansion of tourist/mega-event-related industries</td>
</tr>
<tr>
<td></td>
<td>- reshuffling of household spending toward event-activities;</td>
<td>- sufficient degree of slackness in the labor market</td>
<td>- crowding out effects on household consumption</td>
</tr>
<tr>
<td></td>
<td>- increase in the stock of capital (investment of the previous phase)</td>
<td>- sufficient degree of factor mobility</td>
<td>- increase in the marginal productivity of labor induced by capital stock increase</td>
</tr>
<tr>
<td>Post-event</td>
<td>- increase in the demand of exports, not induced by changes in relative prices or income</td>
<td>- fixed government and trade balance surplus</td>
<td>- positive effect on national income due to new capital stock and international income inflows</td>
</tr>
<tr>
<td></td>
<td>- interests on foreign and national debt are paid back</td>
<td>- sufficient degree of slackness in the labor market</td>
<td>- reduction of unemployment</td>
</tr>
<tr>
<td></td>
<td>- same increase in the stock capital from the previous phase</td>
<td>- full factor mobility</td>
<td>- increase in government revenues from higher national income</td>
</tr>
<tr>
<td></td>
<td>- intangibles (benefits/costs without explicit monetary value)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. A simple illustrative CGE simulation exercise

To better illustrate how the various processes operate in the different phases, we perform some simulation exercises with a rather standard, comparative static, single country CGE model. The economy is here disaggregated into ten industries (agriculture, energy sectors, manufacture, construction, trade, transport, communication, recreations, government services and other 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 (Corong et al., 2017). Structural parameters of the model are obtained (wherever possible) from a national SAM of Italy, extracted from the GTAP9 dataset (Aguiar et al., 2016). A complete description of the model equations and the dataset is provided in the Appendix.\(^8\)

The pre-event phase is simulated by increasing the demand for investment expenditures. As mega-events differ in the structure and level of investment required, two different simulations are considered. In simulation 1A, investment expenditure is increased by 5% in manufacture, constructions, government services, trade and hotels, and other services. In simulation 1B, investment expenditure increases in manufacture and trade sectors only, but the total value of new investment is the same. Total government expenditure is fixed at its baseline level, as well as the exchange rate. Both trade and government balances are therefore flexible and endogenously determined.

Construction in the pre-event phase makes additional infrastructural capital available during and after the event. We therefore assume that the stock of capital increases (+0.5%) in the following two phases. Additionally, during the event consumption expenditures in event-related industries (i.e., trade and hotels, transport, communication and recreations activities) are assumed to grow by 2%.

The post-event phase is simulated through three exogenous shocks. First, the international price of exports is increased by 0.5%, to simulate the increased foreign willingness to pay for domestic goods; second, total factor productivity is raised by 0.1%, to simulate the “brand image” effect; and third, we impose a surplus in both trade and government balances, to repay the interests on government and foreign debt. Total government expenditure and the exchange rate are now endogenously determined. For the sake of simplicity, we assume that factors markets are flexible in all phases, so that labor and capital are fully mobile across sectors. Under the partial mobility assumption, factors would likely be differently allocated across sectors, affecting factors’ marginal productivity.

The magnitude of the exogenous shock is relatively arbitrary, but an effort was made to keep it inside a plausible range for a typical mega-event, like the hosting of Olympic Games. The simulation described is therefore only one example of the many “recipes” one could simulate. For example, one could assume that the increase in the stock of capital concerns only the event-phase, and in the post-event it falls in disrepair.

Results of the simulation exercise are reported in Tables 2 and 3.

---

\(^8\) The model has been coded and implemented with the GAMS language. Code files are available upon request.
Table 2. Results from an illustrative simulation exercise

<table>
<thead>
<tr>
<th>Macroeconomic Variables</th>
<th>Pre-event phase</th>
<th>Event phase (sim. 2)</th>
<th>Post-event phase (sim. 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(sim. 1A)</td>
<td>(sim. 1B)</td>
<td></td>
</tr>
<tr>
<td>Household consump. (%var)</td>
<td>-1.36</td>
<td>-1.29</td>
<td>0.53</td>
</tr>
<tr>
<td>Total investment (%var)</td>
<td>4.04</td>
<td>2.68</td>
<td>-2.40</td>
</tr>
<tr>
<td>Govern. spending (%var)</td>
<td>0 (exog.)</td>
<td>0 (exog.)</td>
<td>0 (exog.)</td>
</tr>
<tr>
<td>Exports (%var)</td>
<td>-0.12</td>
<td>1.18</td>
<td>1.27</td>
</tr>
<tr>
<td>Imports (%var)</td>
<td>0.15</td>
<td>0.23</td>
<td>-0.62</td>
</tr>
<tr>
<td>(Exports - Imports)/GDP (%var)</td>
<td>-0.08</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>(Taxes – Spending)/GDP (%var)</td>
<td>0.02</td>
<td>-0</td>
<td>0.04</td>
</tr>
<tr>
<td>Consumer price index (%var)</td>
<td>0.05</td>
<td>-0.15</td>
<td>-0.31</td>
</tr>
<tr>
<td>Return to capital (%var)</td>
<td>0.07</td>
<td>-0.25</td>
<td>-0.49</td>
</tr>
<tr>
<td>Exchange rate (%var)</td>
<td>0 (exog.)</td>
<td>0 (exog.)</td>
<td>0 (exog.)</td>
</tr>
<tr>
<td>Industry output (%var)</td>
<td>-0.03</td>
<td>0.25</td>
<td>0.44</td>
</tr>
<tr>
<td>Real GDP (%var)</td>
<td>-0.06</td>
<td>0.20</td>
<td>0.65</td>
</tr>
<tr>
<td>Unemployment (%var)</td>
<td>0.45</td>
<td>-1.53</td>
<td>-3.06</td>
</tr>
</tbody>
</table>

Table 3. % changes in total output volume by sector.

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Pre-event phase</th>
<th>Event phase (sim. 2)</th>
<th>Post-event phase (sim. 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(sim 1A)</td>
<td>(sim 1B)</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>-1.0</td>
<td>-0.52</td>
<td>0.53</td>
</tr>
<tr>
<td>Energy sectors</td>
<td>-0.06</td>
<td>0.79</td>
<td>1.05</td>
</tr>
<tr>
<td>Manufacture</td>
<td>0.30</td>
<td>3.17</td>
<td>-0.002</td>
</tr>
<tr>
<td>Government Services</td>
<td>-0.18</td>
<td>-0.03</td>
<td>0.23</td>
</tr>
<tr>
<td>Constructions</td>
<td>3.13</td>
<td>-1.93</td>
<td>-1.56</td>
</tr>
<tr>
<td>Trade and hotels</td>
<td>-0.97</td>
<td>-0.45</td>
<td>1.43</td>
</tr>
<tr>
<td>Transports</td>
<td>-0.67</td>
<td>-0.32</td>
<td>1.22</td>
</tr>
<tr>
<td>Communication</td>
<td>-0.70</td>
<td>-0.57</td>
<td>1.10</td>
</tr>
<tr>
<td>Recreational activities</td>
<td>-1.16</td>
<td>-0.99</td>
<td>1.42</td>
</tr>
<tr>
<td>Other Services</td>
<td>-0.20</td>
<td>-0.40</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Real GDP varies in opposite directions in simulations 1A and 1B (pre-event phase). To understand why, consider how the labor market is modeled and the degree of labor intensity of the different sectors.

Total labor supply is given and is the sum of total labor demand and involuntary unemployment. A wage curve relating real wage to unemployment determines the unemployment rate endogenously (see Eq. 26 of the Appendix). The presence of unused labor resources to employ is crucial for the real income growth: GDP increases if labor demand expands. Indeed, labor demand decreases in simulation 1A but increases in 1B.

To understand why this is the case, consider that any additional element of final demand (extra
investment, private or public consumption) must be financed (internally or externally). This is a major difference between I-O and general equilibrium settings. In I-O models, final demand is fully exogenous, so any extra expenditure directly adds to the national income. In a general equilibrium framework, national income is given by the value of the primary resources, so any increment in an element of final demand must be accompanied by a decrement in some other element. Consequently, when “new” investment is considered in simulations 1A and 1B, one should correctly interpret the scenario as one in which total final demand has simply changed its internal composition, with more demand for some industries and less demand for other industries.

Clearly, the total effect on labor demand depends on the relative labor intensity of the various sectors involved. Ranking the industries in terms of labor intensity is not a trivial exercise, but some information may be obtained by inspecting the labor/capital ratios in our models, which are shown in Table 4. It appears that manufacturing, government services, trade and hotels employ relatively more labor than capital. The opposite occurs for transports, other services, constructions, recreational activities, agriculture and communication. Therefore, real GDP decreases in simulation 1A because it simulates a relative shift in final demand, which mainly benefit capital-intensive industries (whereas 1B is the opposite case).

<table>
<thead>
<tr>
<th>Sectors</th>
<th>L/K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>0.76</td>
</tr>
<tr>
<td>Energy Intensive Sectors</td>
<td>0.96</td>
</tr>
<tr>
<td>Manufacture</td>
<td>1.26</td>
</tr>
<tr>
<td>Government Services</td>
<td>1.18</td>
</tr>
<tr>
<td>Constructions</td>
<td>0.41</td>
</tr>
<tr>
<td>Trade and hotels</td>
<td>2.62</td>
</tr>
<tr>
<td>Transports</td>
<td>0.21</td>
</tr>
<tr>
<td>Communication</td>
<td>0.85</td>
</tr>
<tr>
<td>Recreational activities</td>
<td>0.75</td>
</tr>
<tr>
<td>Other Services</td>
<td>0.27</td>
</tr>
</tbody>
</table>

In simulation 1A the country shows a trade deficit, as the relative price of domestic goods increases. The trade deficit mirrors a net inflow of financial capital from abroad. The opposite occurs in simulation 1B. Only in simulation 1A the resources to finance new investment expenditures come from both taxation and financial inflows.

In the event phase, simulations show an overall positive impact for the economy activity, which is stimulated primarily by the increase in the stock of capital. General price level declines, the international competitiveness of domestic goods and services improves, positively affecting total exports and the trade balance. Real GDP and employment levels both increase, as well as total industry output, whose costs of production are now relatively cheaper.

Results of the post-event phase are qualitatively similar to those generated by simulation 2, as
they both hinge on higher productivity levels. Larger industrial productivity and increased foreign demand enhance the positive impact on GDP, employment and industry output.

At the industry level, the simulations of the three phases show significant differences (Table 3). Some sectors expand, some other contract, depending also on the phase taken into account. The expansion of the construction and manufacturing industries during the pre-event phase comes at the expense of all the other sectors (but the energy sectors, that show a positive increase in simulation 1B). A similar but less evident effect occurs in the event-phase, where the output of two sectors decreases despite the increase in the stock of capital. Higher competitiveness in some industries causes lower competitiveness elsewhere in the economy (i.e., the Dutch disease). The whole productive structure of the country changes, with consequences in terms of income and wealth distribution.

Nonetheless, after the event production expands in all sectors. This may look as a rather positive finding, suggesting that hosting mega-events is always good for the economy, at least in the long run. But this is simply a logical consequence of the investment, creating new capital stock. So the question would be better cast as: are returns on event-related infrastructure higher than alternative investments? Would the economy grow more by hosting a mega-event, or by improving road infrastructure, higher education institutions, etc.? Obviously, our illustrative simulation exercise cannot help in this matter. It may only be worth noticing that the perspective of a large important event is often politically necessary to implement infrastructural projects, which would be beneficial in any case (e.g., a new underground line).

6. Concluding remarks

Getting back to the original question: would you like to get your country hosting the next Olympic Games? To answer, you may consider that hosting countries can reap certain benefits, like an increase in trade, foreign investment, travel and tourism-related spending. They can also take advantage from the improvement in communication and transportation systems, buildings and general infrastructure, which increases the productive capacity of the economy. On the other hand, countries must commit to a considerable investment and many analyses conclude that hosting a mega-event is rarely profitable. Legacies are also heterogeneous, prone to political interpretation and difficult to quantify.

CGE models may turn out to be the right tool to sort the various effects at play and to ascertain the likely net effect, in the short and in the long term. But for the CGE models to work, they must be appropriately designed to serve as the correct test bed. In other words, one has to choose the right closure rules and the right variables to shock.

A serious scientific investigation needs testable models, clearly stated assumptions, verifiable data, accurate interpretation of the results, as well as (in this case) understanding what a CGE model can and cannot do. Indeed, only a transparent and replicable model exercise can serve as a “litmus paper”, to ascertain whether hosting a mega-event is good or bad for an economy.
References


18


Appendix

A1. The model

**Model parameters**

- \( c_{min} \) = minimum consumption level by sector
- \( aH_i \) = share parameter in the LES utility function by sector
- \( s \) = marginal propensity to save
- \( aI_i \) = share parameter in the Cobb-Douglass investment function by sector
- \( aG_i \) = share parameter in the Cobb-Douglass government function by sector
- \( \gamma F_i \) = CES production function share parameter by sector
- \( aF_i \) = CES production function efficiency parameter by sector
- \( \sigma F_i \) = CES capital-labor substitution-elasticities by sector
- \( io_{ij} \) = input-output technical coefficient
- \( \gamma A_i \) = CES Armington production function share parameter by sector
- \( aA_i \) = CES Armington production function efficiency parameter by sector
- \( \sigma A_i \) = CES Armington capital-labor substitution-elasticities by sector
- \( \gamma T_i \) = CET production function share parameter by sector
- \( aT_i \) = CET production function efficiency parameter by sector
- \( \sigma T_i \) = CET capital-labor substitution-elasticities by sector
- \( t_i \) = tax rate on total output by sector
- \( \eta \) = Phillips parameter of the wage curve
- \( PWM_{0i} \) = initial international price of imports
- \( PWE_{0i} \) = initial international price of exports
- \( PCINDEX_{0} \) = initial consumer price index
- \( UNEMP_{0} \) = initial unemployment level
- \( w_{0} \) = initial wage rate
- \( LS_{0} \) = initial stock of labor
- \( C_{0i} \) = initial consumption level by sector
- \( P_{0i} \) = initial prices of composite commodities

**Model variables**

- \( r \) = return to capital
- \( w \) = wage rate
- \( P_i \) = prices of composite commodities
- \( PD_i \) = domestic producer prices of commodities
- \( PPPD_i \) = price of domestic output delivered to home market
- \( PE_i \) = export prices in national currency
- \( PM_i \) = import prices in national currency
- \( PCINDEX \) = consumer price index
- \( KS \) = capital stock (endowment)
LS = labor stock (endowment)  
$X_t$ = domestic sales composite commodity  
$XD_t$ = gross domestic output  
$E_t$ = exports  
$M_t$ = imports  
$XDD_t$ = domestic output delivered to home market  
$TBAL$ = trade balance  
$K_t$ = capital demand  
$L_t$ = labor demand  
$C_t$ = consumer demand  
$CBUD$ = consumer expenditure  
$UNEMP$ = involuntary unemployment  
$Y$ = household income  
$SH$ = household savings  
$S$ = total savings  
$I_t$ = investment demand  
$GBAL$ = government balance  
$G_t$ = government demand by sector  
$G_{tot}$ = total government demand aggregate  
$TAXR$ = total tax revenues

Model equations

Consumer demand for commodities

$P_t C_t = P_t c min_i + \alpha H_t (CBUD - \sum_t c min_i p_t)$  \hspace{1cm} (1)

Household savings

$SH = SY$  \hspace{1cm} (2)

Capital demand function by sector

$K_t = \gamma F_t^{\sigma P_i r (1-\sigma P_i)} [\gamma F_t^{\sigma P_i r (1-\sigma P_i)}]^{\sigma P_i / (1 - \sigma P_i)} (XD_t / \alpha F_t)$  \hspace{1cm} (3)

Labor demand function by sector

$L_t = (1 - \gamma F_t)^{\sigma F_i} W^{(-\sigma F_i)} [\gamma F_t^{\sigma F_i r (1-\sigma F_i)}]^{\sigma F_i / (1 - \sigma F_i)} (XD_t / \alpha F_t)$  \hspace{1cm} (4)

Zero profit condition

$PD_i \cdot XD_i = (r K_i + w L_i + \sum_i o_{ij} XD_j P_j) \cdot (1 + t_0)$  \hspace{1cm} (5)

Total Savings

$S = SH + PCINDEX \times SG \cdot GBAL + ER \cdot TBAL$  \hspace{1cm} (6)

Investment demand function by sector

$P_t I_t = \alpha I_t \cdot S$  \hspace{1cm} (7)

Government demand function by sector

$P_t G_t = \alpha G_t \cdot G_{tot}$  \hspace{1cm} (8)

Total tax revenues

$TAXR = \sum_t t_i \cdot XD_t \cdot \frac{PD_i}{1 + \sigma_f i}$  \hspace{1cm} (9)

Government balance
\[ PCINDEX \cdot GBAL = TAXR - G_{tot} \] (10)

Export supply
\[ E_i = \left( \frac{XD_i}{\alpha T_i} \right) \cdot \left( \frac{Y_i^{T_i}}{PE_i} \right)^{\sigma T_i} \cdot \left[ Y_i^{T_i} \cdot PE_i^{(1-\sigma T_i)} + (1 - Y_i)T_i \cdot (PDD_i)_{i}^{(1-\sigma T_i)} \right]^{\sigma T_i/(1-\sigma T_i)} \] (11)

Domestic supply of domestic good
\[ XDD_i = \left( \frac{XD_i}{\alpha T_i} \right) \cdot \left( \frac{1-Y_i}{PDD_i} \right)^{\sigma T_i} \cdot \left[ Y_i^{T_i} \cdot PE_i^{(1-\sigma T_i)} + (1 - Y_i)T_i \cdot (PDD_i)_{i}^{(1-\sigma T_i)} \right]^{\sigma T_i/(1-\sigma T_i)} \] (12)

CET zero profit condition
\[ PD_i X_i = PE_i E_i + PDD_i XDD_i \] (13)

Import demand
\[ M_i = \left( \frac{X_i}{\alpha A_i} \right) \cdot \left( \frac{Y_i A_i}{P M_i} \right)^{\sigma A_i} \cdot \left[ Y_i A_i^{\sigma A_i} \cdot P M_i^{(1-\sigma A_i)} + (1 - Y_i A_i) \cdot (PDD_i)_{i}^{(1-\sigma A_i)} \right]^{\sigma A_i/(1-\sigma A_i)} \] (14)

Demand for domestic good
\[ XDD_i = \left( \frac{X_i}{\alpha A_i} \right) \cdot \left( \frac{1-Y_i}{PDD_i} \right)^{\sigma A_i} \cdot \left[ Y_i A_i^{\sigma A_i} \cdot P M_i^{(1-\sigma A_i)} + (1 - Y_i A_i) \cdot (PDD_i)_{i}^{(1-\sigma A_i)} \right]^{\sigma A_i/(1-\sigma A_i)} \] (15)

Armington zero profit condition
\[ P_i X_i = PM_i M_i + PDD_i XDD_i \] (16)

Market clearing for labor
\[ \sum_i L_i = LS - UNEMP \] (17)

Market clearing for capital
\[ \sum_i K_i = KS \] (18)

Market clearing for goods
\[ X_i = G_i + I_i + \sum_i i_0 X_i \] (19)

Balance of payments
\[ \sum_i M_i P W_{M_0} - \sum_i E_i P W_{E_0} = TBAL \] (20)

Export price equation
\[ PE_i = ER \cdot PW_{E_0} \] (21)

Import price equation
\[ PM_i = ER \cdot PW_{M_0} \] (22)

Laspeyres consumer index
\[ PCINDEX = \sum_i P_i^{c_{0i}} \] (23)

Total household income
\[ Y = rKS + w(LS - UNEMP) \] (24)

Household expenditure on commodities
\[ GBUD = Y(1 - s) \] (25)

Wage curve
\[ \frac{w}{PCINDEX} \cdot \frac{w_0}{PCINDEX_0} = \eta \left( \frac{UNEMP}{LS} / \frac{UNEMP_0}{LS_0} - 1 \right) \] (26)
A2. Data

Table A1 reports the I-O table used in this study to calibrate the CGE model. Intra-industry flows, household consumption, investment and government consumption by sector are the same as provided by the GTAP9 dataset. The amount of taxes collected, imports and exports flows are determined such that the government balance and the trade balance are both in equilibrium in the calibration year.

Table A1. Italian I-O table used in this study (M$ 2011).

<table>
<thead>
<tr>
<th></th>
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<td>29367</td>
</tr>
<tr>
<td>En. Intens.</td>
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Source: adapted from GTAP v9 database