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The Usefulness of CGE Models in Economic Analysis: Foundations, Strengths, and LimitationsTitle of the article

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Abstract:

This study examines the usefulness of Computable General Equilibrium (CGE) models as tools for ex ante policy analysis in a complex and interdependent global economy. We review the theoretical and empirical foundations of CGE modeling, dis- cussing their microeconomic and macroeconomic structure, robustness, and ability to capture the interdependence of agents' decisions. By integrating behavioral optimization with market equilibrium conditions, these models provide a coherent framework for evaluating the economy-wide effects of external shocks and policy reforms. We emphasize both the analytical strengths and the inherent limitations of CGE modeling, particularly regarding data quality and structural assumptions. To illustrate these aspects, the paper reviews several CGE-based studies of the Algeria–EU Association Agreement. These studies suggest that, although liberalization under the agreement has yielded certain consumer benefits, it has also resulted in trade diversion, fiscal pressures, and sector-specific disruptions. Taken together, this body of work shows the value of CGE models in capturing the complex and sometimes conflicting effects of trade policy reforms.

Keywords: *CGE Models; Policy Simulation; Trade Liberalization; Fiscal Policy; Algeria– EU Association Agreement*.
JEL classification:*C68; F15; O55*.

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1 Introduction

Economists have long grappled with the challenge of understanding how complex systems function— how individual decisions, institutional policies, and unforeseen shocks interact to influence entire economies. Even if theory provides a useful framework, the desire to connect abstract models to real-world outcomes has pushed economiststoward empirical and computational methods with growing intensity. Institutions such as the World Bank, IMF, FAO, and national statistical agencies now provide vast amounts of empirical data, allowing researchers to explore economic mechanisms with greater precision. One of the most striking developments within this paradigm shift is the growing use of large-scale quantitative modeling. These models allow us to combine theory, data, andsimulationtoexamine"whatif"scenariosinvolvingtaxpolicies,tradeliberalization, technological change, or environmental regulation. Through these experiments, we can trace how a single shock reverberates across consumption, production, and trade networks.Thus,analystsgainvaluableinsightsintohowmacroeconomicandsector-specific indicators respond relative to established baselines. In this way, these models make it possible for researchers to gain a more disciplined understanding of the link between policy objectives and their likely economicconsequences.

Amongthearrayofavailablemethodologies,ComputableGeneralEquilibrium(CGE) models have emerged as a central tool within the economic modeling landscape.Thanks to their deep roots in microeconomic theory and general equilibrium principles, CGE modelsofferacoherentframeworkforunderstandinghowmarketsallocateresources— and how those allocations shift in response to policy changes or external disturbances. They gain their analytical strength from their internal consistency and their capacity to captureinterdependenciesthatpartial equilibriumapproachesoftenoverlook.However, their conclusions are not without caveats: they depend heavily on data quality,simplifying assumptions, and the structural choices made during model construction.

Our objective in this study is to assess the practical value of CGE models in applied policy analysis, highlighting both their contributions and their constraints. To make the discussion concrete, we turn to the specific case of Algeria's integration into theAlgeria– EU Association Agreement — a liberalization effort that, contrary to expectations, produced trade diversion effects and welfare losses. Through this example, we provide a concrete context in which to reflect on what CGE models can reveal about economicpolicy outcomes, and equally, what lies beyond their analyticalreach.

Finally, to help guide the reader, the structure of the paper unfolds as follows. Section2outlinesthetheoreticalframeworkofCGEmodels,detailingtheirconceptualroots andeconomicrationale.Section3walksthroughthecoremethodologicalcomponentsin- volved in model development, including data preparation, model formulation, and simulationdesign.Section4surveysmajorapplicationareas,demonstratinghowCGEmodels have been utilized in the analysis of trade policies, taxation strategies, environmental regulations,andmore.Section5appliesthismodelingapproachtotheAlgeria–EUAssociationAgreement,showcasingitsutilityinevaluatingreal-worldpolicyimpacts.Section 6providesacriticaldiscussionofthemodel'sstrengthsandlimitations,reflectingonboth its potential and its constraints. The final section, Section 7, concludes by summarizing theprincipalfindingsandofferingreflectionsonthefutureroleofCGEmodelingineco- nomic policyanalysis.

2 What Is a Computable General Equilibrium (CGE)Model?

Fundamentally,amodelcanbeseenasamentalconstruct—adisciplinedsimplification ofrealitythatallowstheorganizationofideasandthemeasurement oftheoften-conflicting effects of policy choices. Referring to Zidouemba (2014) the modeling process involves both abstraction and synthesis. Computable general equilibrium models belong to this family of analytical tools. They rely on real economic data to simulate how an economy might respond to changes in policy or external conditions—ranging from technological advancements to variations in resource availability or global marketprices.

What distinguishes CGE models is their structural coherence. They are built to reflect the full set of economic relationships among key actors—households, businesses, thepublicsector,andinternationalpartners—withinaconsistentaccountingframework. Thisinternallogicenablesthemtotracehowpolicychangesorexternalshockspropagate through the economy, offering insights into both direct and indirecteffects.

Unlike partial equilibrium or purely econometric models, CGE models use a general-equilibrium perspective. Every decision in the model has a consequence elsewhere: a rise in household demand affects production, production changes incomes, incomes alter savings and investment, and so on. Because these interactions are explicitly considered, the analyst can simulate the reaction of the entire system to a disturbance. The results, when interpreted carefully, can shed light on mechanisms that areotherwise hidden in simple statisticalcorrelations.

The theoretical foundation of CGE modeling is rooted in general equilibrium theory, as formalized by Arrow and Debreu (1954) and McKenzie (1954). These authors demonstrated that, under specific conditions, competitive markets can reach a set of prices at which all goods and factors are simultaneously cleared. Although this result established the theoretical possibility of an economy-wide equilibrium, it remained highly abstract. Turning that insight into a practical analytical tool required another step: the development of numerical methods capable of computing such equilibria in actual economies. Johansen (1960) was among the first to operationalize this idea by building an empirical general equilibrium model for Norway. A few years later, Scarf (1967) advanced thefield by devising iterative algorithms to compute equilibrium prices numerically. Together, these innovations transformed general equilibrium analysis from a theoretical construct into a computational discipline. They thus paved the way for the modern applied CGE models.

As computing power expanded, the structure and data foundations of CGE models also evolved. Early models were based on input–output tables that linked industries through flows of intermediate goods. Later, social accounting matrices (SAMs) enriched these tables by including institutions such as households, firms, and the government. This made it possible to explicitly model income distribution and fiscal channels. Yet, asShovenandWhalley(1992)observed,nouniversallystandardizedprocedureyetexists for performing the entire sequence of data adjustment, calibration, andcomputation. Each CGE model must therefore strike its own balance between theoretical rigor, data constraints, and the analytical purpose it is designed toserve.

A decisive step in the spread of CGE modeling came with the creation of the General Algebraic Modeling System (GAMS) by Brooke, Kendrick, and Meeraus (1992). For thefirsttime,economistswereabletowritecomplexsystemsofnonlinearequationsand solve them efficiently on a computer. This innovation made it possible to explore more realisticsituations—dynamicsettings,imperfectcompetition,andeconomiesofscale— that earlier frameworks could not easily handle. Subsequent methodological advances and econometric estimates of key parameters, such as substitution elasticities (Hudson and Jorgensen, 1974), further grounded these models in empirically observedbehavior.

From a formal perspective, a CGE model can be summarized in a single compactexpression:

$$Y = M\,(X, B, \gamma)$$

Here, (Y) represents the set of endogenous variables describing the state of the economy, (X) the exogenous or policy variables that drive it, (B) a set of structural parameters,and (γ) the calibration parameters that ensure the model reproduces a base-yearequilibrium. The function $M(\cdot)$ embodies the system of equations linking these components — typicallynonlinearandsolvednumerically.Whatmattershereisnotthealgebraiceleganceof the system of equations but their capacity to generate meaningful interpretations. They are able to trace the adjustments of prices, output, trade flows, and welfare following a change in policy or externalconditions.

Building on this formal foundation, CGE models have diversified considerably, givingrisetoabroadfamilyofapproachestailoredtodiverseresearchandpolicyobjectives. This variation reflects the flexibility of CGE models. Some are theoretical and analytical, designed to explore ideas with minimal empirical constraint. They allow us to iso- late causal mechanisms and examine how equilibrium behavior emerges from basic assumptions. Others are more quantitative and parameter-driven, especially when analytical solutions are impractical; they focus on estimating the scale of effects underspecific scenarios. In practice, the most applied models combine both perspectives. These ap- plied models integrate comprehensive datasets on production structures, consumption patterns, and fiscal policies to simulate actual economies. As a result, they have become essential tools in policy analysis, offering virtual laboratories in which proposedreforms can be tested and evaluated prior to real-worldimplementation.

Beyond their analytical orientation, CGE models also differ in scope and geographic coverage,reflectingthediversequestionstheyaredesignedtoaddress.GlobalCGEmodels such as GTAP (Hertel and Tsigas, 1997), and LINKAGE (Van der Mensbrugghe, 2005) were developed to study worldwide trade liberalization, notably during the Uruguay Round. These models are particularly useful for identifying how trade agreements can produce asymmetric outcomes, benefiting some countries while disadvantagingothers.

Other CGE models are designed with a regional focus. These models are used to explore economic integration processes or policy coordination efforts within specific blocs, such as the European Union or regional alliances in North Africa, includingAlgeria. No- tablecontributionsinthisareaincludestudiesbyDecaluwéetal.(2001) and Rutherfordand Tarr (1998), which investigate how regional cooperation in trade or taxation can affect memberstates.

At the national level, CGE models are often employed to analyze domestic policy reforms— rangingfromtradeandfiscalpoliciestostructuraladjustments.Thesecountry- specific models are tailored to capture the unique institutional and economic contexts of individualnations.ExamplesincludemodelsconstructedforTunisia(Haykel,2004),Morocco (Rutherford &Tarr, 1997), and Algeria (Mennad, 2019). These applications demonstrate the value of focusing on local dynamics, which might otherwise be lost inbroader, globalmodels.

Takentogether,thesevariationsrevealboththeversatilityandthecomplexityofCGE modeling. The framework is flexible enough to represent a global economy yet detailed enough to capture, to some extent, the institutional and structural characteristics of a singlecountry.

3 CGE Model ConstructionMethodology

Developing a Computable General Equilibrium (CGE) model involves both theoretical design and technical implementation. It is a process in which the modeler translates the abstract logic of economic behavior into a numerical framework that can replicate real-world dynamics and predict the effects of policy interventions. Typically, the process begins by identifying the key macroeconomic feedback mechanisms relevant to the research question. This is followed by a careful calibration phase, in which theoretical relationships are aligned with empirical data to create

a working representation of the economy. In the final stage, the modeler designs policy simulation scenarios and selects the numerical techniques needed to solve the modelefficiently.

3.1The LoopingMode

A crucial early step in building a CGE model is to determine its closure rule—the mechanismthroughwhichmacroeconomicbalance,particularlybetweeninvestmentandsavings, is restored once other behavioral and accounting relationships have been specified. As Starr (2011) notes, in its theoretical form, general equilibrium requires several conditions to hold simultaneously: full employment of labor, factor payments equal to marginal productivity, consumption decisions driven by real income, and a fixed levelof investment. Because these assumptions can over-specify the system, one variable is usuallytreatedasexogenoussothatthemodelcanbesolved.Inpractice,themodelstructure often separates into two interconnected parts: a microeconomic core, representing the behavior of individual agents, and a macroeconomic block that enforces the aggregate equilibriumconditions.

This dual structure, described by Zidouemba (2014), provides a flexible foundation for extendingthemodeltodifferentmacroeconomiclinkages.AnextendedCGEframework can,forexample,beusedtostudybalance-of-paymentsadjustments,taxreforms,subsidy redesign, fiscal-deficit financing, or welfare effects of policy distortions. In this framework,twomainclosurerulesarecommonlycontrasted:theKeynesianandtheKaldorian approaches.

In a Keynesian closure, the adjustment between savings and investment occurs through the multiplier mechanism. Investment is taken as exogenous, and nominal wages are typically fixed by institutional or contractual arrangements. With prices adjusting only partially, firms expand output and employment in response to higher demand rather than to changes in relative prices. The resulting rise in income feeds back into greater savings, closing the loop between savings and investment. Because the adjustmentoperates through aggregate demand rather than individual optimization, it takes place at the macroeconomic level. In open-economy or fiscal variants, price movements can further influence budgetary and external balances, ultimately affecting incomedistribution.

The Kaldorian closure, by contrast, rests on differences in saving propensities across in- come groups, making income distribution the key adjustment mechanism. In thisframework, nominal wages are typically assumed to be institutionally fixed, while firms set pricesinawaythatdeterminestheirprofitshare.Investmentistakenasgiven,andequilibrium requires that aggregate savings adjust through redistribution in favor of profits. Fallingrealwagesraisetheprofitshare,therebyincreasingaggregatesavingsandrestoring balance between savings and investment. The general price level plays a role in reconciling nominal and real magnitudes by influencing real wages, the real exchange rate, and the real interest rate.

3.2Reference Data and ParameterCalibration

Once the model's behavioral structure is established, the next step is to anchor it in data. Constructing a CGE model involves selecting specific functional forms for production and utility—often of the Constant Elasticity of Substitution or Cobb–Douglas type—and assigning numerical values to their parameters. Since these parameters are not directly observable, modelers rely on a snapshot of the economy in a single year to derive values that align with real-world observations. This procedure, known as calibration, seeks to ensurethatthemodelreproducesthebase-yearequilibriumexactlywhennopolicyshock is applied.

Typically, calibration unfolds in two main stages. The first is the construction of a com- prehensive database called the Social Accounting Matrix (SAM). The SAM consolidates all economic transactions of a given year into a square matrix that records flowsamong production sectors,

institutional agents, and the rest of the world. It includes, at a mini- mum, three accounts: the institutional account (households, firms, and government), the production account (factors of production, industries, and goods), and the external ac- count (which captures trade and balance-of-payments relationships). The SAM therefore provides both the empirical foundation, and the internal consistency check for the entire modeling framework (Shoven &Whalley, 1992).

The second stage is the numerical calibration of the parameters themselves. Here, the model is effectively solved "in reverse": given the base-year equilibrium recorded in the SAM, one computes the set of parameter values that allow the theoretical equations to replicate that equilibrium. These include scaling factors, substitution elasticities, and share parameters for which econometric estimates are unavailable. The calibration processisdeterministicandaimstopreserveinternalconsistencybetweenthemodel'sequations and the data foundation it restsupon.

3.3Simulations and SolutionStrategies

OncetheCGEmodelhasbeencalibrated,itbecomesacontrolledenvironmentfortesting differenteconomicscenarios.Simulationsinvolveintroducingexogenousshocks—policy changes, external disturbances, or technological innovations—and solving the model to observe how the economy adjusts. Widely used software packages such as GAMS and GEMPACK make it possible to solve CGE systems either as constrained optimization problems or by explicitly computing the first-order conditions implied by agents' optimizationbehavior.Eachapproachhasitsstrengths:directoptimization offers simplicity and numerical robustness, while analytical resolution provides greater transparency about the underlyingmechanisms.

In practice, two main computational strategies are often used. The factor-pricebalancing approach,outlinedbyZantman(1995),beginsbytargetingequilibriuminfactormarkets. Starting from an initial set of product prices, the model searches for wage and interest rates that balance labor and capital supply with demand, given the structure of productionfunctions.Oncefactormarketsclear,thesepricesdeterminehouseholdincomes, which are then used to assess equilibrium in goods markets. This method suits static modelsparticularlywellanddoesnotrequiretheassumptionofconstantreturnstoscale.

Asecondmethod,theproduct-pricebalancingstrategy,istypicallyemployedindynamic settings. Here, equilibrium is solved sequentially across time, treating each period as temporary equilibrium. Intertemporal variables such as capital stock are updated after each round, allowing the model to track the economy's evolution over time. After calibration ensures that the base-year equilibrium is reproduced, the model cansimulate how the economy responds to various shocks. Each scenario yields a new general equilibrium,offeringacomparative-staticviewofhowprices,output,andtradeflowsadjust. Interpreting these results, however, requires caution. CGE models are simplified representations of complex systems, and their outcomes depend on several factors: data quality, behavioral realism, and the appropriateness of the closure rule. They are bestviewed asanalyticaldevicesforexploringeconomicmechanismsratherthanasforecastingtools. A solution is achieved when agents' expectations are consistent with the prices generated within the model—at that point, the model has served its purpose: clarifying how individual behaviors interact to affect macroeconomicbalance.

4 Applications of CGE Models in EconomicAnalysis

Inrecentdecades,CGEmodelshavebecomeacornerstoneofappliedeconomicresearch. Over time, improvements in data availability and computing power have allowed re- searchers to build increasingly detailed models that capture the socio-economic consequences of policy reforms across

diverse national and international settings. Their use has expanded well beyond single-economy analyses, giving rise to multi-country and multi-regional frameworks that reflect the deep interdependence of the global economy. Fromtradeandtaxationtopoverty,energy,andenvironmentalpolicy,CGEmodelinghas proven a flexible tool for exploring how shocks and policy measures propagate through the complex network of economicrelationships.

4.1TradeReforms

Tradeliberalizationhaslongbeenoneofthemostprominentandthoroughlystudiedap- plications of CGE modeling. Building on the neoclassical foundations laid by Dervis, de Melo, and Robinson (1982), CGE trade models have been widely used to evaluate tariff reductions, regional integration, and multilateral cooperation agreements. Their central purpose is to assess how such policy reforms affect trade flows, fiscal revenues, and welfare—particularlyindevelopingeconomieswheretariffincomerepresentsasubstantial source of public revenue. By simulating alternative policy scenarios involving tariffs or exchange rates, CGE models make it possible to explore the often delicate balance between promoting trade openness and maintaining fiscalstability.

One of the earliest and most influential examples was the multi-country model developed by Deardorff and Stern (1981), which included 34 economies and revealed how thebenefitsofliberalizationareunevenlydistributed—somecountriesgainconsiderably, while others face transitional costs. Foundational theoretical work by Srinivasan and Whalley (1986), and later refinements by Brown et al. (1988) helped formalize the classic two-country, two-good, two-factor CGE framework that still underpins most trade policy analysistoday.

Several large-scale and widely adopted models—such as IFPRI's global CGE model, Decaluwé'sEXTERframework(2001),andtheGlobalTradeAnalysisProject(GTAP)—have since become essential tools for analyzing trade policy reforms. These frameworks havebeenappliedinnumerouscountry-specificstudies,includingRutherford'sanalyses ofMorocco(1997)andTurkey'sEUaccession(1998),Haykel (2004) on Tunisia, and Mennad (2019) on Algeria. Collectively, these applications illustrate the ability of CGE models to capture both the broad and nuanced effects of trade reforms, especially in emerging and developingeconomies.

4.2PublicFinances

CGE models have also played a critical role in the study of public finance, providing de- tailed insights into how fiscal policies determine economic outcomes. One of the earliest applications in this area was by Shoven and Whalley (1972), who used a CGE framework to analyze the effects of tax reform. Their later work (1984) extended this approach to explore the joint influence of trade and taxation policies, with particular attention to efficiency and income distribution.

Sincethen,CGEmodelshavebeenwidelyusedtoassessthemacroeconomicanddistributionalimpactso fgovernmenttaxationandexpenditurepolicies.Forexample,Dabla Norris and Feltenstein (2005) modeled the effects of tax evasion in Pakistan and showed thatexcessivelyhightaxratescanworsenfiscaldeficitsbydrivingfirmsintotheinformal sector.Similarly,FeltensteinandHa(1999)examinedinfrastructureinvestmentinMexico and found that, although better infrastructure lowered production costs andencouraged private investment, higher interest rates partly offset these gains—illustrating possible crowding-outeffects.

Otherstudieshavefocusedonthedesignandreformoftaxsystemsinbothdeveloped and developing economies. Arndt et al. (2009) analyzed the introduction of a Value- Added Tax (VAT) in Mozambique, while Ballard et al. (1985) conducted a comparable exercise for the United States. Ball and Feltenstein (2001) used a CGE framework to evaluate government interventions for

distressed banks in Bangladesh. Fiscal CGE models have also been applied to broader macroeconomic policy questions, including monetary–fiscal interactions and debt sustainability, as illustrated by Devarajan, Lewis, and Robinson (1993).

Collectively, this body of work shows the versatility of CGE models in analyzing fiscal policy. Whether used to evaluate tax reforms, public investment, or fiscal consolidation, these models help clarify the channels through which government actions influence efficiency, growth, and income distribution.

4.3 Poverty and Inequality

One of the most socially relevant applications of CGE modeling concerns poverty and inequality. By linking macroeconomic shocks to household-level outcomes, thesemodels allow analysts to trace how policy changes affect income distribution and welfare. Such integration of macro and micro perspectives makes it possible to evaluate the equity im- plications of economic reforms in a consistent and data-drivenway.

Anotableexampleistheworkby Robilliardetal.(2008),whoconstructedamicro–macro CGE model to examine how the Asian financial crisis affected poverty levels in Indonesia. Similarly, Devarajan and Go (2003) applied this methodology in support of Poverty Reduction Strategy Papers (PRSPs) across developing nations, helping governments de- signmorepro-poorpolicyinterventions.Hérault(2006)furtherextendedthisapproach byinvestigatinghowalternativegrowthpathsinfluencebothpovertyandinequalityout- comes. Thesestudiesreflectabroadershiftintheuseof CGEmodels—fromtoolsfocusedprimarilyonmacroeconomicperformancetoinstrumentscapableofcapturingthedistributional and social consequences of economic change. This evolution has positioned CGE models as key resources for policymakers seeking to design reforms that foster inclusive and equitabledevelopment.

4.4 Agriculture

The agricultural sector has long served as a key domain for the application of CGEmodels, particularly in developing countries, where it often represents a major source of employmentandiscriticaltofoodsecurity.Recognizingthis,institutionssuchastheInternationalFoodPolicyResearchInstitute(IFPRI)havedevelopedawiderangeofagriculture- focused CGE models to support initiatives like the Comprehensive Africa Agriculture Development Programme(CAADP).

An interesting study by Breisinger et al. (2009) evaluated the role of agriculturalinvestmentinalleviatingpoverty.Similaranalyseswereconducted byDiao et al. (2012), and earlier by Yotopoulos and Fafchamps (1986), who examined agricultural dynamics in countries such as Taiwan, India, and Mexico. These worksdemonstratehowCGEmodelingcanuntangletheintricatelinkagesbetweenagricultural productivity, income distribution, and rural development. By capturing the sec- toral interdependencies that link agriculture to the rest of the economy, CGE models helpclarifyhowshiftsinagriculturalpolicyorinvestmentaffectbroadermacroeconomic outcomes—particularly in contexts where rural livelihoods are most vulnerable. This capacity makes them indispensable tools for evaluating the role of agriculture ininclusive and sustainable development.

4.5 Human Development

As CGE modeling has matured, its scope has expanded to encompass broader human development concerns beyond traditional economic metrics like efficiency and output. Contemporary models

increasingly incorporate social dimensions—such as health, education, and regional inequality—to better understand how macroeconomic policies in- fluence welfare and human capabilities. With support from global institutions such as the World Bank, these enriched CGE models strive to bridge the gap between economic reform and tangible improvements in quality of life (World Bank, 1995).

Earlycontributionsincludethestudy byBranda˜o,Hertel,andCampos (1994),whichanalyzed how fluctuations in world prices influence income distribution between rural and urban Brazil, and Taylor et al. (1980), who investigated macroeconomic adjustment processes in the same context. In a different setting, Alderman and Robinson (1978) developed a model for South Korea to explore the interplay between industrial development, educational access, and income inequality.

Subsequent applications in countries such as Ghana, Tanzania, and Zambia have focused on how investments in education and healthcare influence welfare outcomes, particularlyforvulnerablepopulations. Morerecentcontributions—includingthe one by Jacoby (2013)—have deepened the analysis of education policy, wage formation, and regional disparities in low- and middle-income economies. These studies show the potential of CGE models as tools not only for economic evaluation, but also for designing policies that promote inclusive and equitabledevelopment.

4.6Climate Change and EnvironmentalIssues

Over time, CGE modeling has expanded to address environmental challenges such as climate change, resource degradation, and sustainable land use. Early efforts, including Gérardetal.(2002),examinedhowshiftsinclimatepatternsinfluenceagriculturaloutput and trade flows. A later study by Thurlow et al. (2008) broadened this perspective to include adaptation strategies and the wider macroeconomic effects of declining land productivity. These models have shown how climate-related shocks propagate across sectors and how instruments such as carbon taxes or targeted subsidies can mitigate theirimpact.

Environmental degradation, particularly soil erosion and land loss, has been another majorfocuswithindynamicCGEframeworks.Alfsenetal.(1996)analyzedtheeconomic consequences of declining land productivity in Nicaragua, while similar work was carried out for Ghana by Diao and Sarpong (2011), and for Tanzania by Wiig (2001). Collectively, these studies bring light to the long-term economic risks of environmental neglect and the value of investing in sustainable land management.

Energy policy has also been a central area of CGE modeling since the oil shocks of the 1970s. Supported by institutions such as the World Bank, early models sought to understand the structural changes required to adapt to volatile energy prices. Hudson andJorgenson(1974)pioneeredtheanalysisofenergysubstitutionandcomplementarity, while Borges and Goulder (1984) explored how energy use interacts with labor and capital accumulation in the United States. These studies laid the foundations for integrated energy–environment CGEmodels.

Bythe1990s,environmentalexternalitiesbegantobeexplicitlyincorporatedintowelfare measures, marking a turning point in CGE methodology. This led to "nested models," described by Beaumais and Schubert (1999), which integrated environmental processes with economic mechanisms in a unified analytical framework. PerroniandWigle(1994) embedded environmental damages within utility functions, transforming CGE models into comprehensive tools for environmental policy analysis.

Subsequentadvances,includingtheworkbyBruniauxetal.(1992),Goulder(1992),and Dissou (2005), extended these insights to carbon mitigation, climate policy, andthevaluationofenvironmentalquality.Thistrajectoryultimatelytracesbackto Nord

haus (1977), whose pioneering integration of climate and economic systems continues to shape the field of environmental CGE modeling today.

5 The Use of CGE Models to Evaluate the Algeria–EU As- sociationAgreement

Among the many applications of Computable General Equilibrium (CGE) models, the assessment of regional trade agreements occupies a central place. Such frameworks are particularly suited to capturing the complex interactions between domestic structures and international liberalization. In the case of Algeria, the implementation of the Association Agreement with the European Union (EU) has generated a substantial body of CGE-based research aimed at quantifying its economic and social consequences. These studies, though diverse in scope and methodology, converge on a nuanced conclusion: tradeliberalizationundertheagreementhasbroughtamixofexpectedgainsandunforeseen costs that continue to influence Algeria's policydebate.

Early modeling efforts, such as Bentabet (2000), provided an initial quantitative exploration of Algeria's trade reform. His simulations suggested that tariff reductions under theassociationframeworkreducedgovernmentrevenueandpublicexpenditure,weighing on economic growth. Ziad (2007) reached similar conclusions, finding that the combined effects of tariff dismantling and lower fiscal receipts led to declines inGDP, house- hold consumption, and national savings. In his view, liberalization placed downward pressure on the state's capacity to sustain domestic demand, exposing the fiscal fragility that can accompany openness when diversification islimited.

Later analyses offered a more differentiated picture. Oukaci and Kherbachi (2008),using amodelwithexplicitsectorallinkages,foundthatremovingtariffsonindustrialproducts improved household welfare by lowering consumer prices and stimulating demand. Yet thesamereformhadadverseeffectsonwagesandprivateinvestment,revealingdistributionaltrade-offsoftenhiddenbehindaggregateindicators.Boumediene(2014)expanded onthisworkandshowedthatthepartnershipproducedacombinationoftaxlosses,con- tractions in savings and investment, and an overall decline in prices, even ashouseholds benefitedfromcheaperimports.Theseoutcomesreinforcedconcernsthatshort-termconsumer gains may come at the expense of long-term productivecapacity.

The most recent contribution is that of Mennad (2019), who employed a disaggregated Social Accounting Matrix (SAM) covering nineteen sectors of the Algerian economy.Her model captured both direct and indirect inter-sectoral linkages and found that the Association Agreement generated significant trade-diversion effects, welfare losses, and structural imbalances. Sectors exposed to European competition contracted, while non- tradable and protected activities adjusted more slowly.By integrating a detailed SAM within a national CGE framework, Mennad's study moved beyond aggregate welfare measurestorevealtheunevenimpactsofliberalizationacrosstheproductionstructure.

Takentogether,thesestudiesshowthetwosidesofAlgeria'stradeintegrationwiththe EU. Liberalization improved access to consumer goods and enhanced certain efficiency measures,butitalsostrainedpublicfinances,discouragedinvestment,andwidenedsec- toral disparities. This body of work demonstrates the capacity of CGE models to link fiscal, trade, and welfare effects within a single analyticalframework.

More broadly, Algeria's experience serves as a cautionary case for developing countriesnegotiatingagreementswithmoreadvancedpartners.ItillustrateshowCGEanalysis can inform more balanced policymaking—revealing not only potential gains but also the transitional costs and structural adjustments that accompany integration. As Algeria continues to refine its modeling tools—by updating data sources, introducing dynamic components, and calibrating behavioral

responses—CGE analysis will remain central to guiding policies toward inclusive and sustainabledevelopment.

6 Strengths and Limitations of CGEModels

Over time, Computable General Equilibrium (CGE) models have become one of the most versatileandintellectuallyrigorousinstrumentsinappliedeconomics.Theirmainstrength lies in how they connect theory and data, turning abstract behavioral assumptions into quantifiable scenarios that inform policy choices. Built on microeconomic foundations, theyreplicatethedecisionsofhouseholds,firms,andgovernments,aswellasthemarketmechanismsthatco ordinatethem.ThismakesCGEmodelswellsuitedtotracetheripple effectsofpolicyreforms,identifywhobenefitsandwholoses,andevaluatethetrade-offs between efficiency and equity that accompany structuralchange. The strength of CGE modeling resides above all in its structural consistency. The behavioral equations that define the decisions of households, firms, and the public sector are rootedinoptimization:householdsmaximizeutility,firmsmaximizeprofits,andmarkets clear through price adjustments. This coherent architecture ensures that all simulated outcomes are internally consistent—a property that gives the results analytical credibility, even when the models themselves must simplify reality.Thanks to this rigor, CGE models have become a shared analytical language among economists andpolicymakers. They are used worldwide to compare scenarios, perform ex ante evaluations, and assess the macroeconomic and distributional consequences of reform. Their flexibility allows them to be adapted to fiscal, trade, agricultural, or environmental issues within frameworks calibrated to national or regionaldata.

Yet their strengths come with clear limits. The first concerns data quality.The Social AccountingMatrix(SAM)thatunderpinsmostCGEmodelsisoftenderivedfromincompleteoroutdatednat ionalaccountsandrepresentsonlyasingleyear.Thisstaticsnapshot canconcealongoingstructuralchange,makingresultssensitivetomeasurementerrorsor inconsistentreporting.

A second limitation arises from the simplifying assumptions about behavior and market structure. Many models depict economies with perfect information, full employment, and perfectly competitive markets—conditions seldom met in reality.As Harris (1984) noted, ignoring imperfect competition or product differentiation can distort how price formation and strategic behavior are represented.

The static nature of most models further limits their ability to address long-term or intergenerational issues. Schubert (1993) observed that such frameworks "ignore future generations of agents who will be affected by present decisions," since savings and in- vestment are often treated in reduced form. The representative-household assumption, thoughconvenient,alsomasksheterogeneityacrossincomegroups,reducingthemodel's capacity to capture distributional dynamics. Grandmont (1977) pointed out that applied modelstypicallyassumecompletemarketsovertime—astrongabstractionineconomiesmarked by institutional constraints and missing markets.

Behavioral assumptions also tend to simplify human motivation. CGE agents are modeled as self-interested optimizers, leaving little room for altruism, social norms, or institutional behavior. This abstraction keeps the analysis tractable but narrows its realism.

Financial linkages pose another challenge. Because data for a financial social accounting matrix are scarce, many CGE models omit banking and credit markets. As Robinson (1991) warned,

neglecting financial intermediation can obscure how policy shocks prop- agate in economies where finance increasingly shapes growth and volatility.

Beyondthesestructuralissues,themostimportantlimitationconcernsinterpretation.As Bchir et al. (2002) emphasized, CGE results are not definitive answers but disciplined thought experiments—quantitative illustrations of how mechanisms might operate un- der given assumptions. Their value lies less in numerical precision than in clarifying reasoning, making assumptions explicit, and helping policymakers visualize the consequences of alternative strategies. Proper interpretation requires awareness of what the model captures and what it leaves aside: informal activity, expectation formation, and institutional change—all central to real-worldadjustment.

In this sense, CGE models embody the paradox of all formal representations: they gain analytical clarity only by sacrificing some of the richness of the world they seek to describe. Their power lies in synthesis—the capacity to make coherent what would otherwisebeintractable.Theirweaknessliesin abstraction—theinevitablesimplificationsthat render them incomplete. The true merit of CGE models therefore depends not ontechnical complexity, but on how carefully they are interpreted and integrated into thebroader policy conversation. Applied carefully, they provide a disciplined meeting ground between theory and policy, between quantitative analysis and informed judgment. Usedmechanically, they risk turning into technocratic exercises detached from the social realities they are meant toexplain.

7 Conclusion

ThewidespreadadoptionofComputableGeneralEquilibrium(CGE)modelsbynational and international institutions reflects their growing importance as instruments of quantitative economic analysis. Their strength lies in bridging the gap between traditional Keynesian macroeconometric models and partial-equilibrium approaches. By integrating individual behavior, income flows, and macroeconomic equilibrium within a single framework, CGE models offer a powerful means of understanding the complex interdependencies that define moderneconomies.

Therangeofapplicationsreviewedinthisstudy—fromtradeandfiscalpolicytoagriculture,poverty,andenvironmentalissues—showshowCGEmodelshavebecomeessential laboratories for analyzing the effects of external shocks and policy reforms. Their ex-ante simulations allow policymakers to anticipate the likely outcomes of proposed measures, assess the magnitude and direction of adjustments, and evaluate distributional implicationsbeforeimplementation.InAlgeria'scase,CGE-basedstudieshavebeenparticularly revealing: they help explain the country's cautious approach to tradeliberalization under the Algeria–EU Association Agreement and its subsequent reassessment of tradepolicy.Throughsuchanalyses,CGEmodelstranslateabstractpolicyquestionsinto structured, quantifiable insights that inform real-worlddecision-making.

Theusefulnessofthesemodels,however,dependscriticallyonthequalityoftheirempirical foundations. Updated and reliable data—especially in the form of detailed Social Accounting Matrices—remain essential for credible calibration. Future developments in CGE modeling should continue to move beyond static formulations, incorporating dynamic mechanisms that better capture adjustment overtime.

Ultimately, the value of CGE models lies not in the precision of their forecasts but in their ability to clarify assumptions, structure economic reasoning, and supportinformed policy dialogue. When applied thoughtfully and grounded in sound data, they remain indispensable analytical tools—helping researchers and policymakers alike understand economic systems and design more effective, inclusive, and sustainablereforms.

References

Alderman, H., & Robinson, S. (1978). Education, income distribution, and development policy in South Korea: An applied general equilibrium model (World Bank Staff Working Paper No. 287). World Bank.

Alfsen, K. H., Bye, B., & Holmøy, E. (1996). The economic cost of land degradation in Nicaragua: A computable general equilibrium approach. *Environmental and Resource Economics*, 7(2), 203–221.

Arndt, C., Robinson, S., & Tarp, F. (Eds.). (2009). *Taxation in a low-income economy: The case of Mozambique*. Routledge.

Arrow, K. J., & Debreu, G. (1954). Existence of an equilibrium for a competitive economy. *Econometrica, 22*(3), 265–290.

Ball, C., & Feltenstein, A. (2001). Banking crises and financial liberalization: Effects on emerging markets. *World Development*, 29(7), 1215–1233.

Ballard, C. L., Shoven, J. B., & Whalley, J. (1985). General equilibrium computations of the marginal welfare costs of taxes in the United States. *American EconomicReview*, 75(1), 128–138.

Bchir, M.-H., Decreux, Y., Guérin, J.-L., & Jean, S. (2002). MIRAGE, un modèle d'équilibre général calculable pour l'évaluation des politiques commerciales. *ÉconomieInternationale*, 89–90, 109–153.

Beaumais, O., & Schubert, K. (1999). Environment and welfare in a general equilibrium model. In *Handbook of environmental and resource economics*. Edward Elgar.

Bentabet, B. (2000). *Un modèle d'équilibre général calculable pour l'économie algérienne* [Doctoral dissertation, Université d'Oran].

Borges, A. M., & Goulder, L. H. (1984). Decomposing the impact of higher energy prices on long-term growth: The role of capital substitution, sectoral mix, and technological change. *Journal of Economic Dynamics and Control*, 7(1), 115–137.

Boumediene, H. (2014). *Les effets de l'accord de partenariat euro-méditerranéen sur les finances publiques en Algérie: Évaluation à l'aide d'un MEGC* [Doctoral dissertation, Université de Tlemcen].

Brandão, A. S. P., Hertel, T. W., & Campos, A. C. (1994). Distributional implications of international agricultural trade liberalisation: A case study of Brazil. [Working paper].

Breisinger, C., Diao, X., & Thurlow, J. (2009). *Modeling agricultural growth and poverty in Mozambique: Insights and policy implications* (IFPRI Discussion Paper 00621). International Food Policy Research Institute.

Brooke, A., Kendrick, D., & Meeraus, A. (1992). *GAMS: A user's guide* (Release 2.25). The Scientific Press.

Brown, D. K., Deardorff, A. V., & Stern, R. M. (1988). Computational analysis of the effects of U.S. trade policy: Multilateral, bilateral, and unilateral approaches. *The World Economy*, 11(2), 165–186.

Bruniaux, J., Rotillon, G., & Schubert, K. (1992). Carbon taxation and economic change: A CGE application to the French economy. *Energy Economics*, 14(3), 177–182.

Dabla-Norris, E., & Feltenstein, A. (2005). The underground economy and its macroeconomic consequences. *Journal of Policy Reform*, 8(2), 153–174.

De Melo, J., & Robinson, S. (1989). Product differentiation and the treatment of foreign trade in computable general equilibrium models of small economies. *Journal of International Economics*, 27(1–2), 47–67.

Deardorff, A. V., & Stern, R. M. (1981). A disaggregated model of world production and trade: An estimate of the impact of the Tokyo Round. *Journal of Policy Modeling*, 3(2), 127–152.

Decaluwé, B., Martens, A., & Savard, L. (2001). *La politique économique du développement et les modèles d'équilibre général calculable: Une introduction à l'application de l'analyse mésoéconomique aux pays en développement*. Presses de l'Université de Montréal.

Devarajan, S., Lewis, J. D., & Robinson, S. (1993). External shocks, purchasing power parity, and the equilibrium real exchange rate. *World Bank Economic Review*, 7(1), 45–68.

Devarajan, S., & Go, D. S. (2003). The 1-2-3 PRSP model for poverty reduction strategy papers in Africa: Explanatory notes and simulations. In A. F. Shorrocks & R. van der Hoeven (Eds.), *Growth, inequality, and poverty: Prospects for pro-poor economic development* (pp. 300–331). Oxford University Press.

Diao, X., & Sarpong, D. B. (2011). *Poverty implications of agricultural land degradation in Ghana: An economy-wide, multimarket model assessment* (IFPRI Discussion Paper 01070). International Food Policy Research Institute.

Dissou, Y. (2005). Cost-effectiveness of the performance standard system to reduce CO2 emissions in Canada: A general equilibrium analysis. *Resource and Energy Economics*, 27(3), 187–207.

Feltenstein, A., & Ha, J. (1999). An analysis of the optimal provision of public infrastructure: A computational model using Mexican data. *Journal of Development Economics*, 58(1), 219–230.

Goulder, L. H. (1992). Do new tax revenues from carbon permits accentuate or offset the deadweight loss of the tax system? *Journal of Environmental Economics and Management*, 23(2), 151–176.

Grandmont, J.-M. (1977). Temporary general equilibrium theory. *Econometrica*, 45(3), 535–572.

Harris, R. (1984). Applied general equilibrium analysis of small open economies with scale economies and imperfect competition. *American Economic Review*, 74(5), 1016–1032.

Hertel, T. W., & Tsigas, M. E. (1997). Structure of GTAP. In *Global trade analysis: Modeling and applications* (pp. 13–73).

Hudson, E. A., & Jorgenson, D. W. (1974). U.S. energy policy and economic growth, 1975–2000. *Bell Journal of Economics and Management Science*, 5(2), 461–514.

Jacoby, H. D., & Schafer, A. (2013). Technology detail in a multisector CGE model: Transport under climate policy. *Energy Economics*, 27(1), 1–24.

McKenzie, L. W. (1954). On equilibrium in Graham's model of world trade and other competitive systems. *Econometrica*, 22(2), 147–161.

Mennad, N. (2019). L'aboutissement de la ZLE entre l'Algérie et l'UE: Quel impact sur l'économie algérienne? *Les Cahiers du CREAD*, 35(3), 5–40.

Oukaci, K., & Kherbachi, H. (2008). Impact de la libéralisation commerciale sur l'intégration et le développement de l'économie algérienne: Évaluation par un modèle d'équilibre général calculable. *Les Cahiers du CREAD*, 24(83), 5–46.

Perroni, C., & Wigle, R. M. (1994). International trade and environmental quality: How important are the linkages? *Canadian Journal of Economics*, 27(3), 551–567.

Robilliard, A.-S., Bourguignon, F., & Robinson, S. (2008). Crisis and income distribution: A micro-macro model for Indonesia. In F. Bourguignon & L. Pereira da Silva (Eds.), *The impact of economic policies on poverty and income distribution: Evaluation techniques and tools* (pp. 93–122). World Bank and Oxford University Press.

Robinson, S. (1991). Macroeconomics, financial variables, and computable general equilibrium models. *World Development*, 19(11), 1509–1525.

Rutherford, T. F., Rutström, E. E., & Tarr, D. G. (1997). Morocco's free trade agreement with the EU: A quantitative assessment. *Economic Modelling*, 14(2), 237–269.

Rutherford, T. F., & Tarr, D. G. (1998). *Trade liberalization and endogenous growth in a small open economy: A quantitative assessment* (Vol. 97, No. 6). World Bank Publications.

Scarf, H. E. (1967). The approximation of fixed points of a continuous mapping. SIAM *Journal on Applied Mathematics*, 15(5), 1328–1343.

Schubert, K. (1993). Les modèles d'équilibre général calculable: Une revue de la littérature. *Revue d'Économie Politique*, 103(6), 775–825.

Shoven, J. B., & Whalley, J. (1972). A general equilibrium calculation of the effects of differential taxation of income from capital in the U.S. *Journal of Public Economics*, 1(3–4), 281–321.

Shoven, J. B., & Whalley, J. (1984). Applied general-equilibrium models of taxation and international trade: An introduction and survey. *Journal of Economic Literature*, 22(3), 1007–1051.

Shoven, J. B., & Whalley, J. (1992). *Applying general equilibrium*. Cambridge University Press.

Srinivasan, T. N., & Whalley, J. (1986). *General equilibrium trade policy modeling*. MIT Press.

Starr, R. M. (2011). *General equilibrium theory: An introduction*. Cambridge University Press.

Taylor, J. E., Yunez-Naude, A., et al. (1980). Macroeconomic adjustment processes in Brazil: A social accounting matrix approach. *World Development*, 8(5–6), 319–330.

Thurlow, J., Zhu, T., & Diao, X. (2008). *The impact of climate variability and change on economic growth and poverty in Zambia* (IFPRI Discussion Paper 00890). International Food Policy Research Institute.

Van der Mensbrugghe, D. (2005). *Linkage technical reference document*. Development Prospects Group, The World Bank.

World Bank. (1995). *World development report 1995: Workers in an integrating world*. World Bank Publications.

Yotopoulos, P. A., & Fafchamps, M. (1986). Agricultural development: An international perspective. *World Bank Research Observer*, 1(1), 17–41.

Zantman, A. (1995). Modèles d'équilibre général calculable et répartition des revenus dans les pays en voie de développement: Quelques éléments d'évaluation. *Revue Tiers Monde*, 411–442.

Ziad, M. (2007). *L'impact des accords euro-méditerranéens: Une analyse quantitative* [Doctoral dissertation, Université d'Oran].

Zidi, M. (2013). CGE modelling for economic policy evaluation: Education and regional inequality in Tunisia. *Tunisian EconomicStudies* Working Paper.

Zidouemba, P. (2014). *Sécurité alimentaire, productivité agricole et investissements publics au Burkina Faso: Une analyse à l'aide d'un modèle d'équilibre général calculable dynamique et stochastique* [Doctoral dissertation, Université Montpellier].