Application of CGE Models in GST: A Literature Review

by
Anushuya, Karam Pal Narwal
Junior Research Fellow, Haryana School of Business, GJUS&T, Hisar, India.
Professor, Haryana School of Business, GJUS&T, Hisar, India.
anushuya24@gmail.com, karampalhsb@gmail.com

Abstract: GST is now accepted all over the world and countries are using it for its sales tax system. Its concepts and impacts are analyzed with various aspects and techniques. Analyzing it with the help of CGE is at introduction stage and this paper assesses different literatures on it to find out CGE application in GST by examining 21 research papers of the period 1989-2012. The major finding of the paper is that CGE is mostly used for welfare effect of GST and various aspects are still waiting to open.

Key words: CGE, GST, Taxation, Input-Output Tables and Welfare.
JEL classification: D6, D57, D58.

1 Introduction

Policymakers and professionals have interest in evaluating the direct and indirect effects of particular policy measures on economic outcomes. They are interested in the assessment of actual and future impact of various policy reforms. There is a very important tool since the beginning of 1980s i.e. CGE that help in analyzing various reforms. Taxation reforms are also analyzed by it whether they are Direct or Indirect tax reforms. Impact of Income tax, wealth tax and corporate tax reforms are quantified by various researchers [e.g. González-Torrabadella and Pijoan-Mas (2006), Hidayat et al. (2013), Fajernas (2004)]. As far as indirect taxation is concerned, sales tax, excise duty, import duty etc. also examined through CGE technique [e.g. Matovu et al. (2009), Chadha et al. (1998), Lledo (2005), Ferreira Filho et al. (2007)].

This paper concentrates on GST, an indirect tax. World has adopted GST eagerly. 134 countries have adopted it by one way or the other way. In fact, it has become necessity of each and every country today. It is a tax on goods and services. Its special feature is input credit. It proves very helpful in economic growth, welfare, distribution, poverty, inequality and competitiveness.

GST is analyzed with various dimensions using different techniques. Regression is used by different researchers [e.g. Valdkhani and Layton (2004), Valdkhani (2005), Murrell and Yu, (2000), Palil and Ibrahim (2011)]. Welfare effect is quantified using LES [e.g. Creedy (2001), Johnson (1999), Creedy and Sleeman (2005)]. GST is very popular concept all over the world and it is analyzed with various techniques. CGE is also a powerful technique in the field of economic yet GST concept is not studied with this technique as it should be. To fill this gap, this paper is designed to review existing literature related to it.

This paper presents a conceptual detail of GST and CGE. Then it looks insight the existing literature with the view to find out areas of its applications. The paper is written with the purpose of assessing introduction and implications of GST using CGE. This paper contributes to the existing literature by providing an analysis of work done with this tool in various areas and countries so that policymakers and researchers find some ground for further work.

This paper is divided into three parts. First part throws light on GST and CGE models. Second part presents research methodology and areas of application of CGE in GST. Last part shows concluding remarks with some research gap.

2 GST AND CGE

2.1 Concept of GST

GST comprises tax on each stage of sale and purchase in the supply chain of value addition. It
does not make any difference in goods and services with the point of view of taxation. It also provides full credit for input tax. It is a consumption based tax. It is a tax made on supply of goods and supply of services. Supply of goods mean transfer of right to use goods and any supply of not goods means supply of services. Tax is levied on value addition. Though tax is calculated on full value and then a credit of input tax already paid is given till the goods or services is sold to final consumer who get no benefit of input credit as he will pay full cost of goods/services.

2.2 Concept of CGE Model

CGE models are the modern version of Walras’ model of competitive economy. CGE is an economy wide model that describes the motivations and behavior of all producers and consumers in an economy and the linkages among them. It tells the direction and magnitude of change of policy reform. It presents versatile empirical simulation laboratory for quantifying effect of economic policies and external shocks of domestic economics. Computable means that these models present numerical results which are computed from a numerical database that has a set of coefficients and parameters in their equations. This database uses input-output accounts for a particular year which shows flows of commodities and factors between industries, households, governments, imports and exporters. Various elasticities such as substitution elasticities between different input to production processes, price and income elasticities of demand by households for various commodities and foreign elasticities of demand for exported products are included in this database. In short, these models present computed results in numerical numbers. Equilibrium means in equal state. In these models, demand and supply are assumed same. Prices for each commodity and factors in these models are such that they produce demand and supply in equal terms. Equations of commodities and factors are in that way they produce equilibrium on the economy. In other way, CGE models produce result in numerically than merely illustratively using data of actual countries or regions. They use real-world situations (Dixon, 2006). First CGE model with 20 cost-minimizing industries and a utility maximizing household sector was developed by Johansen in 1960 for Norway to estimate household price and income elasticities. But after it there was a big gap in CGE modeling. Handling of huge data and quantifying shocks were the two reasons that made it popular in 1970s. A lot of work was done that had appeared in leading journals and in books. Since 1970s to 2014, there were international meetings and workshops of CGE modelers regularly. A lot of text books for graduate students are available now. Now it has become an emerging field for policy makers. GTAP is the latest invention of CGE modelers which is establishing new record of popularities (Dixon, 2006).

3 Research Methodology

This paper uses 21 research papers of conceptual and practical nature. Sampling is based on availability of research papers which come under the preview of this paper. The papers are collected from various databases such as JSTOR, Emerald, Willy online Library, Google Scholar etc. The period for the study is 1989 to 2013. This paper includes studies of different countries such as: Thailand, India, Australia, USA, Uganda, South Africa, Canada and Brazil etc. Figure 1 shows no. of studies included according to various aspects of GST. Summary of these studies can be seen in Appendix 1.
4 Application of CGE models for GST

This section discusses the applications of CGE in the area of GST according to various key aspects of GST such as welfare, distribution, competitiveness, poverty, inequality and revenue productivity etc.

4.1 Welfare effect

Hamilton and Whalley (1989) analyzed welfare effect of Canada. They used applied general equilibrium model with 44 industries i.e. 35 are traded and 9 are non-traded, 23 consumer expenditure commodities and 42 household groups divided according to household income assuming Canada as a small, open and price taking economy. They acknowledged margin industries in their model. Equivalent incomes were calculated by using Hicksian method. The parameters of the model are calibrated to a 1980 benchmark equilibrium data set and literature-based elasticity estimates. They simulated seven proposals for the study and found that replacing federal tax by broadly based sale tax provided more gain than replacing provincial sales taxes although this gain is very small. Distributional impact was so small that this can be offset by direct taxes.

Lledo (2001) analyzed Brazilian Indirect tax system with the two objectives named the reason of not approving a comprehensive reform of the tax system and to know redistributive effect of tax system. He achieved these two objectives in the light of fiscal adjustment restriction. For the purpose of the study, A-K model is used giving detail description of CGE models and found that younger generation would be beneficial from this proposal and this gave politicians ground for their vote in its favour.

Wittwer & Kym (2002) quantified impact of GST on Australia’s wine industry with the help of CGE model. They found export-oriented premium segment in gain at the expense of non-premium segment of wine industry.

Rege (2002) presented general equilibrium model for India using Leontief and Cobb-Douglas production function for production and consumption structure of the model and found that replacing existing indirect tax of India with VAT led reduction in welfare. Agricultural sector played a good role in welfare of India.

Go et al. (2004) quantified welfare, revenue and distributional effect of South Africa’s tax reform with the help of CGE model which was developed by Lofgren et al. for IFPRI in 2001. They took 2003 as base year and used data from SAM developed by Claude Van Der Merwe from Quantec. They solved simulations with the help of GAMS and solver PATH. They took 10 households income deciles for the study. CES function was used for production. They included 6 sectors and 49 commodities in the model. Four production factors such as capital, high-skilled, semi-skilled and unskilled labor were included in the model. They used various elasticities from the existing literature. They made four simulations for the analysis such as removal of VAT, increase in VAT by 50%, zero VAT for food and replace tariff with uniform VAT. They found that VAT negatively affected welfare of Low income households and progressivity of overall tax structure.

Matovu et al. (2009) examined welfare effect of Indirect taxes on households using CGE model. They presented impact of welfare on production and firm activities. Their result indicated that reforms are of progressive in nature which was similar with existing studies’ results. They agreed to zero rates all food items so that low income households get benefited from it. They found that taxation of petrol and rising excise duties made this tax regressive on this part only. They found that removal of VAT increased welfare of richer households and decline the poor
one. They found that VAT implementation proved beneficial for poor people of Uganda. Marquez-Pena (2010) analyzed welfare effect of proposed indirect tax reform of Mexico using general equilibrium model. He found that 15% tax rate on food, medicine, educational services and press and editorial products will give additional tax revenue of 9300 million pesos to the government.

Acosta-Margain (2011) quantified distributional and efficiency effect by developing CGE model which included informal sector for Mexican VAT if its base would be broaden. He reached on the conclusion if low-income households would purchase from informal sector then Regressivity of VAT broadening could be done less. Taxing all goods at the current standard rate in the proposal of harmonizing tax rate would enhance revenue.

Michael et al. (2011) examined welfare effect of indirect taxes using general equilibrium model and taking pollution as an output of production and consumption activities. For their analysis, they made two types of scenario with and without revenue constraints. Their result showed that various conditions made in the study led to more revenue generation and welfare gain subject to source of pollution i.e. consumption or production. The study didn’t even mention the name of the country which Indirect Tax reforms were talked about and it also lack the data sources used for the study.

Bye, Strom and Aviststant (2011) compared three proposals i.e. current indirect tax, Vat with some services and uniform VAT by using computed general equilibrium (CGE) model which used 41 private, 8 government production and 26 consumer goods. They calibrated their model on 1995 national accounts data. They found that welfare effect is correlated with number of goods and services included in VAT. VAT with only goods had more welfare than VAT including some services with goods in and Uniform VAT had superior welfare.

Auriol and Warelters (2012) examined Marginal Cost of Public Funds (MCF) in 38 African countries using Simple general equilibrium model. Data came from national accounts. They considered informal economy in their model. They found VAT as lowest cost tax in their study.

4.2 International Competitiveness

Meagher and Parmenter (1993) analyzed short-term implications of Australia’s tax reform of 1992 by using a general equilibrium model. They didn’t talk about changes in the composition of Australia’s foreign trade. They reached on the conclusion that GST made smaller impact on cost-sensitive industries facing International competition in comparison to former taxes.

4.3 International Trade

NCAER (2009) analyzed the impact of GST on international trade by using data of 60 sectors including 4 mining sectors, 33 manufacturing sectors and 16 service sectors from Annual National Survey and National Accounts Statistics (NCAER) with the help of CGE model. This paper calculated revenue neutral GST rate in between 6.2% to 9.4%. The paper expected efficient allocation of factors of production that lead growth in GDP and export.

4.4 Distributional Effect

Chowdhury (1991) estimated the welfare and distributional effect of VAT and excise taxes of equal yield on Bangladesh taking the help of a small open economy General equilibrium model. In his study, he found that poorer households are adversely affected by this reform and there was a need to have different rate structure to improve the efficiency of an indirect taxation.

Devarajan, Jitsuchon and Sussangkarn (1991) analyzed the impact of proposed VAT reform in Thailand. For their study, they used multi sector general equilibrium model with certain assumptions and took data from social accounting matrix (SAM). They assumed four cases having different rates of excise and GST tax. They found that exported manufactures and agriculture sectors as winner and some non-tradable service sectors as looser. They found that GST would increase revenue and had a
slightly favorable effect on the distributional income in Thailand.
Sajidifar et al. (2012) quantified impact of tax reform of Iranian economy by using a CGE model calibrating data of various sources such as input-output data, national accounts etc. Existing literature was also used for data. They simulated results for three VAT rates i.e. 3%, 45 and 10% They found that government revenue was increased and household welfare was declined. GDP declined due to implementing of VAT. They made suggestion that Iranian government should increase VAT rate to increase its revenue.

4.5 Macroeconomic Effect
Frankel et al. (1991) examined macroeconomic effect of VAT harmonization on Europe in 1992 with the help of General equilibrium model. They used time profile for the study. Their result indicated that VAT harmonization led internal conflicts among countries as effects were not spread evenly across income groups, generation and countries. Ajakaiye (1999) analyzed sectoral and macroeconomic effect using CGE model for Nigeria to suggest way of minimizing the adverse effects. For this purpose, he prepared a questionnaire having 100 VATable organizations i.e. 30 manufacturing organizations, 70 services of which 70 questionnaire were suitable. He used Cobb-Douglas as production function. Base year was 1991. He used data from federal office of statistics and the central Bank. He used 29 sector input-output Table. He found that VATable organizations were treating VAT as cost. Three simulations were made for the purpose of analysis.
Lledo (2001) analyzed Brazilian Indirect tax system with the two objectives named the reason of not approving a comprehensive reform of the tax system and to know macroeconomic effect of tax system. He achieved these two objectives in the light of fiscal adjustment restriction. For the purpose of the study, A-K model is used giving detail description of CGE models and found positive long run income growth. All factors are increasing due to adoption of single VAT in comparison of existing taxes. His results made a base for political parties to vote in its favour. Giesecke and Tran (2009) developed a general equilibrium framework which used VAT model in detail to analyze macroeconomic and sectoral effect of Vietnam’ complex tax system. They suggested single rate which is budget neutral instead of three tax rates along with desire o removing many exemptions. They used input-output table of 2005 for the study and found that private real consumption would increase due this single rate VAT.
Ahmad et al. (2011) presented macro and microeconomic effect of Pakistan using CGE and microsimulation structure which is an extension of Caroration and Orden (2007) model by using dataset of SAM prepared by Darosh et al. 2004. This SAM also used data from input-output tables, national accounts, Pakistan Integrated Household survey 2002, Pakistan rural household survey 2002 and Pakistan Economic survey 2002. They used 2002 as base data. LES utility function was used for consumption and production structure had two items namely intermediate inputs and value added to give the final output. They further divided into two parts such as domestic sale and export. Constant Elasticity Transformation (CET) function was used for export and CES was used for import of Pakistan. They used CES function for the four different value addition sources named skilled and unskilled labor, capital and land. They modeled output price as the combination of export and local price. They used 12 agricultural sectors, 16 industrial sectors and 6 service sectors for the analysis. They made for simulations regarding GST for the study. Their result showed that all simulations has increased in the poverty instead of reducing it and has increased government revenue and investment. They recommended applying reform process slowly.
Hernandez (2012) evaluated impact of increase in VAT rates replacing parafiscal taxes on employment of Colombia. For his study, he divided labor into two parts- formal and informal labor. He used MEGATAX model and SAM of 2005 for the analysis. He used effective tax rate instead of normal rates in his study. His result
showed that Increase in VAT rate had negative impact on household consumption and output. He used a wage curve developed by Blanchflower and Oswald, 1994 for unemployment and the Harris-Todaro approach was adopted to analyze worker’s decision regarding to work in formal or informal sector.

5 Conclusion

Both GST and CGE are very popular all over the world. GST is a powerful concept in the field of indirect taxation. CGE models are used to analyze various areas of Taxation i.e. direct and indirect tax reforms, increase and decrease in tax rate, tax base of income tax, corporate tax and carbon tax etc. Different researchers concentrate their studies on them. But a few studies combine both. Most of the work of these studies is related to welfare effect. International competitiveness, macroeconomic effect and distributional areas are also touched. But since there are various areas remain untouched such as impact of GST on poverty alleviation, inflation, distribution and international trade etc. where CGE models can be used. There is no single country and year that has more share than others in selected studies. Instead of being the popular concept and technique, these findings leave a question unanswerable i.e. why few researchers involve in it? These questions no doubt lay a path for further research in this area.

References


Lledo, V.D. (2005), Tax systems under fiscal adjustment: a dynamic CGE analysis of the Brazilian tax reform, IMF working papers series, WP/05/142.


Appendix 1: Summary of selected studies on GST using CGE model

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Country Name</th>
<th>Author(s) Name</th>
<th>Study Year</th>
<th>Base Year</th>
<th>Data Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>India</td>
<td>Sameer R. Rege</td>
<td>2002</td>
<td>1989-90</td>
<td>CSO, National accounts Statistics, Annual Survey of Industries, IES-PF and AIITS.</td>
<td>Formulation of Indian tax model and quantify welfare effect by four simulations about Indian VAT.</td>
</tr>
<tr>
<td>2</td>
<td>Canada</td>
<td>Hamilton and Whalley</td>
<td>1989</td>
<td>1980</td>
<td>Existing literature, Family Expenditure Survey, Input-output Table and Revenue Canada.</td>
<td>Includes margin industries and finds more gain in replacing federal tax by broadly sales tax.</td>
</tr>
<tr>
<td>5</td>
<td>Colombia</td>
<td>Hernandez</td>
<td>2012</td>
<td>2005</td>
<td>SAM-2005.</td>
<td>Quantify impact of increase in VAT rate and finds negative impact on households’ welfare and output.</td>
</tr>
<tr>
<td>6</td>
<td>South Africa</td>
<td>Go et al.</td>
<td>2004</td>
<td>2003</td>
<td>SAM-2003 developed by Claude Van Der Merwe and existing literature.</td>
<td>Examines negative effect of VAT on the welfare of low income households and overall progressivity of tax.</td>
</tr>
<tr>
<td>7</td>
<td>Mexico</td>
<td>Marquez-Pena</td>
<td>2010</td>
<td>2000</td>
<td>Input Product Matrix by Hernandez and ENIGH, 2000.</td>
<td>Quantify additional tax revenue of 9300 million pesos of imposing 15% VAT on food, medicine, educational services etc.</td>
</tr>
<tr>
<td>8</td>
<td>Mexico</td>
<td>Acosta- Margain</td>
<td>2011</td>
<td>n.a.</td>
<td>n.a.</td>
<td>Formulation of CGE model for Mexico which includes informal sector and analyzes revenue, welfare effect of VAT.</td>
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<tr>
<td>9</td>
<td>Bangladesh</td>
<td>Chowdhury</td>
<td>1991</td>
<td>1984-85</td>
<td>SAM and National Accounts.</td>
<td>Examines welfare effect taking small open economy and finds adverse effect on poor households of VAT.</td>
</tr>
<tr>
<td>11</td>
<td>Iran</td>
<td>Sajadifar et al.</td>
<td>2012</td>
<td>1999</td>
<td>Existing literature and SAM-1999 published by Iranian Central Bank.</td>
<td>Finds increase in government revenue and decline in household welfare and GDP. Suggests increment in VAT rate.</td>
</tr>
<tr>
<td>12</td>
<td>Europe</td>
<td>Frankei et al.</td>
<td>1991</td>
<td>n.d.</td>
<td>Existing literature.</td>
<td>Analyses that harmonization of VAT leads internal conflicts among countries due to uneven broaden of</td>
</tr>
<tr>
<td>No.</td>
<td>Country</td>
<td>Authors</td>
<td>Year</td>
<td>Reference Detail</td>
<td>Findings</td>
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<tr>
<td>13</td>
<td>Pakistan</td>
<td>Ahmad et al.</td>
<td>2011</td>
<td>Pakistan Integrated Household survey, Pakistan rural household survey, Pakistan economic survey, SAM.</td>
<td>Quantify increment in poverty, government revenue and investment. Recommends implementation of reforms gradually.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>India</td>
<td>NCAER</td>
<td>2009</td>
<td>ASI-2004-05, NAS-2008 and IOTT 2003-04.</td>
<td>Analyses impact of proposed GST on international Trade. Results show efficient allocation of factors of production due to GST.</td>
<td></td>
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<tr>
<td>15</td>
<td>Norway</td>
<td>Bye, Strom and Aviststant</td>
<td>2011</td>
<td>SAM and National accounts.</td>
<td>Finds correlation between welfare effect and no. of goods and services included in VAT. Uniform VAT shows higher welfare.</td>
<td></td>
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<tr>
<td>17</td>
<td>Vietnam</td>
<td>Giesecke and Tran</td>
<td>2009</td>
<td>Input output table-2005 and existing literature.</td>
<td>Formulates CGE model which models VAT in detail and finds increase in macroeconomic factors due to single VAT than Three rates of VAT.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Brazil</td>
<td>Lledo</td>
<td>2001</td>
<td>National accounts and existing literature.</td>
<td>Quantify that younger generation will benefits from single rate VAT using A-K model.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>African countries</td>
<td>Auriol and Warelters</td>
<td>2012</td>
<td>National accounts and existing literature.</td>
<td>Examines role of MCF and finds that among various taxes VAT is the lowest cost tax.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Australia</td>
<td>Wittwer &amp; Kym</td>
<td>2002</td>
<td>National accounts and existing literature.</td>
<td>Presents impact of GST on wine industry.</td>
<td></td>
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</table>