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Thematic and Spatial Concentration of CGE Models' Application to Policy Research

Khalid Siddig[1]

Abstract

Many countries in the developing world lack the required capacities and data to provide evidence-based policymaking. As a consequence, they apply a trial-and-error approach to their exchange rate, trade and domestic tax policies, among others. Some countries base their policies on the experiences of other countries that are not necessarily similar in terms of economic structure, sectoral linkages and trade openness. This could be partially justified as well by the difficulty of basing economic policies on researched evidence due to the forward and backward linkages that prevail in any economy, which necessitates *ex post* and *ex ante* policy impact analysis on the entirety of economic actors. This reality was recognized during the 1960s by researchers and Johansen (1960) was the first to envisage a solution for it in the form of what is currently known as Computable General Equilibrium (CGE) models. The importance of CGE models rests on their ability to provide economy-wide impact assessments with huge flexibility in capturing a detailed representation of the economy depending on the availability of data. Despite the widespread use of CGE models, no comprehensive review of their applications to the different geographical regions of the world, the different types of problems they contributed to and the different disciplines they addressed is available. This kind of review is expected to show their usefulness and identify the regions, themes and disciplines that lack their applications and, hence, to direct future research. These are the main objectives of this study, which starts by exploring the history of CGE models, including the intensity of their applications worldwide and the areas of research in which they have been applied through the time, with a special focus on the period between 1980 and 2014. The study also explores classifying CGE applications by the kind of services they have provided to advise policymaking, especially in developing countries. Afterwards, the study focusses on four countries to provide deep assessments of CGE applications and identify areas for future research using CGE models. The selected countries are Palestine, Israel, the Sudan and Nigeria. The selection of these countries is related to research projects in which the author is involved, as well as personal interest. The study reviews all the CGE applications to the selected countries, their areas of applications and the type of problems they addressed.

Keywords: CGE application, policy research, Palestine, Sudan, Nigeria.

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1 Introduction

Computable General Equilibrium (CGE) models have a long and established history of contributions to policy assessments all over the world ever since the publication of the first CGE-based study by Johansen (1960), which was applied to Norway and designed to address policy issues. Since then, numerous policy analyses have been undertaken based on CGE models and applied for both developed and developing countries. A comprehensive review of the CGE literature[2] based on research included in the Scopus database[3] showed more than a thousand[4] of CGE-based studies were conducted during the period between 1980 and 2014. Although this search does not reflect the entirety of CGE publication in the last three decades and a half, it provides rough indications about the importance of such a method and its contribution to policy analysis and the policymaking process globally. CGE applications began, and flourished, in the developed world, led by the United States (USA) and Europe. Early CGE models applied to the USA were designed to address policy issues such as public finance, international trade and environmental policy (Devarajan and Robinson, 2013a). Their applications to developing countries, although not as numerous as those of the developed world three decades ago, also started to appear during the eighties, and various applications have followed during the last three decades.

Applications of CGE models in the last three decades and a half are found to cover 19 different disciplines. The percentage share of each discipline is shown in Figure 1, with the lowest 6 disciplines aggregated into one category with the name "multidisciplinary and other areas".[5] This discipline-wise classification shows CGE applications to be concentrated around Economics, Econometrics and Finance, which alone account for about one third of total applications, followed by the social sciences, which together with the former constitute one half of total CGE

[2] This CGE literature review was conducted based on Scopus database search in which four words are used, namely, "CGE" and "computable general equilibrium". This search can be easily replicated using similar keywords. Note that this search was performed on Wednesday, September 10, 2014; therefore, later searches may yield additional results.

[3] Scopus is a bibliographic database that contains abstracts and citations for academic journal articles, books, chapters and other research work. It comprises 53 million records, 21,915 titles from 5000 publishers and it belongs to Elsevier. For more details, visit: http://www.elsevier.com/online-tools/scopus.

[4] The results of the search showed 1027 studies of which 854 are published as journal articles, 65 as conference proceedings, 15 as book chapters, 14 as review articles and 4 as books.

[5] The aggregated disciplines include: Multidisciplinary, Chemical Engineering, Arts and Humanities, Immunology and Microbiology, Physics and Astronomy, and Psychology. Each of them represents less than 0.5% of the total publications.

applications (Figure 1). Environmental science came third with 15%, followed by energy (8%); agricultural and biological science (6%); and business, management and accounting (6%).

Considering the time dimension, only one CGE study was published in 1980, assessing the impact of trade policy and income distribution in Colombia (de Melo and Robinson, 1980).

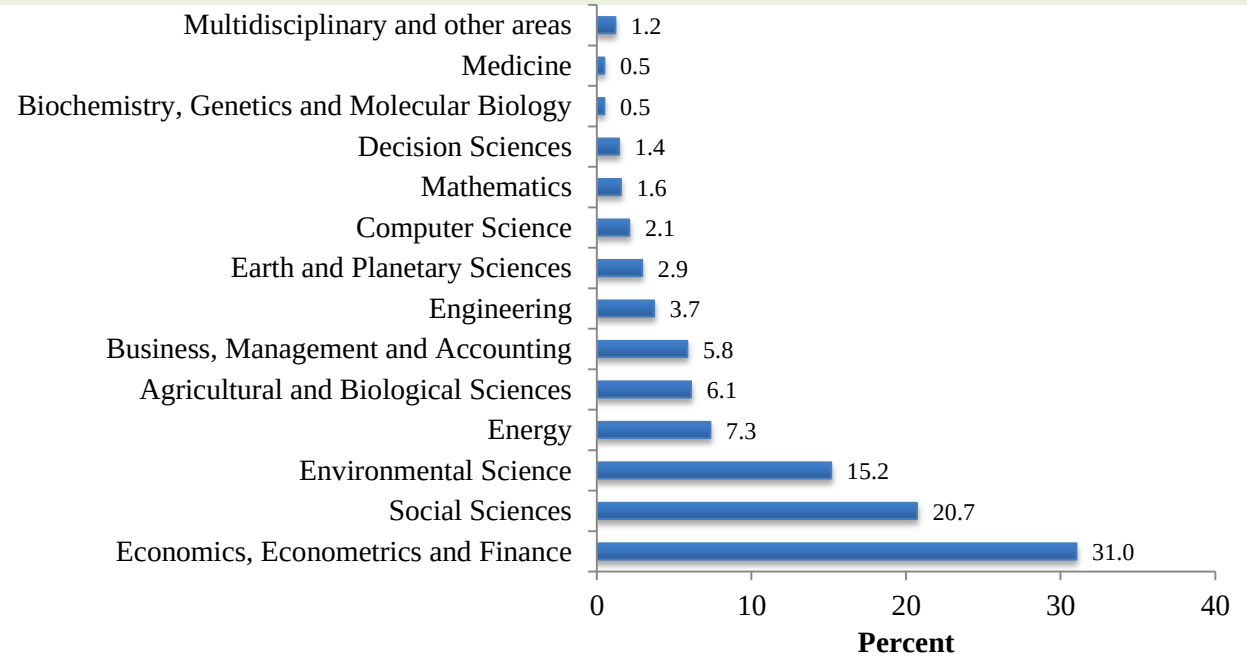

Figure 1: Subject area of CGE applications during the period between 1980 and 2014 (percentage).

During the period between 1980 and 1989 (10 years), 14 CGE applications were published: one study investigated the macroeconomic structure of CGE models with a case study applied to the USA (Robinson and Roland-Holst, 1988); one study used a simple, one-sector analytic model to show the treatment of exports and imports, and external closure rules adopted in small-economy single-country CGE models (de Melo and Robinson, 1989); and three studies were of a more mathematical and computerization focus (Codsi and Pearson, 1988; Pearson, 1988; Pearson and Rimmer, 1985). The remaining studies were focused on developing countries and/or taking one country from the developing world as a case for application. In terms of discipline, CGE studies in the 1980s focused mainly on trade policies (de Melo and Robinson, 1982; 1980; Bergman, 1982; de Melo, 1988). However, other research areas were also covered, including natural resources (Devarajan, 1988; Higgs, 1986), energy (Seddighi, 1985), structural change and fiscal policies (Ezaki, 1987; Lewis and Urata, 1984), rural-urban migration (Becker et al., 1986), and capital markets (Devarajan and Offerdal, 1989).

In order to observe the development of CGE applications through time, a database search was confined to the last ten years (2005-2014). Results show 698 studies were undertaken, accounting for 68% of the total CGE-research published between 1980 and 2014. These results

indicate that CGE models have proven useful and were able to continuously develop their capabilities to accommodate the growing complexities of economies through the use of advancements in technology, such as increases in the speed of processors and storage capacities. This is further confirmed by the fact that in the year 2014 alone (although not finished yet), 79 CGE studies were published. The published CGE studies during the last ten years (2005-2014) are shown in Figure 2, which exhibits this growing trend.

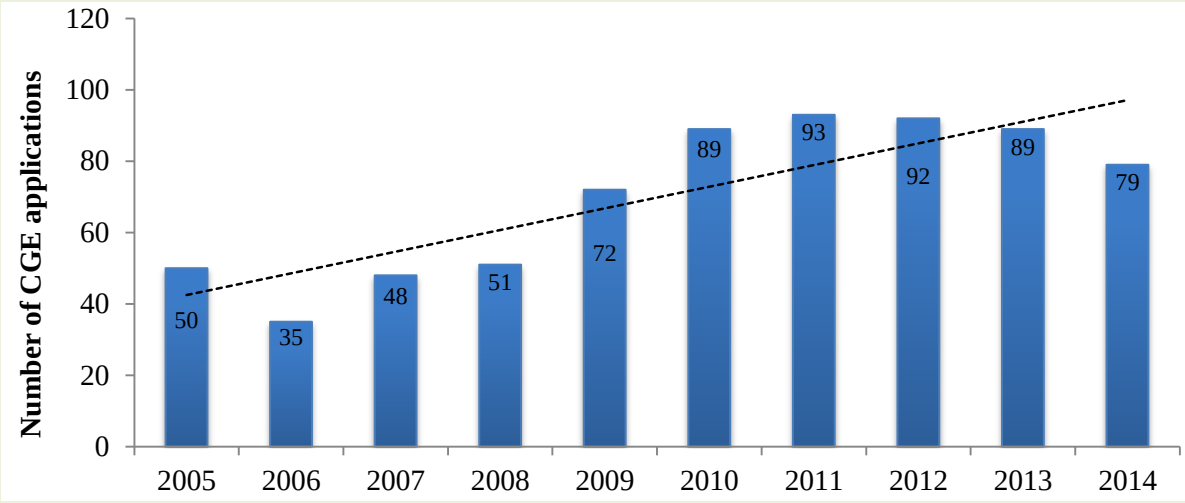

Figure 2: Number of CGE applications during the last ten years (2005 -2014)

Further exploration of the literature of the last ten years by considering discipline shows that the share of Economics, Econometrics and Finance was higher in the first five years (2005-2009) than in the last five years (2010-2014). From 2010 to 2014, the share of this discipline has remained almost constant. Energy and environmental science witnessed growing trends throughout the same ten-year period, followed by engineering, e.g. Dai et al. (2012, 2011); Fujimori et al. (2014); Thepkhun et al. (2013), as shown in the Appendix.

In the development context, Devarajan and Robinson (2013a) provided a comprehensive review and classification of CGE studies devoted to addressing the challenges of development policymaking. They found CGE models to provide four distinct services to policy making in developing countries: (1) Providing quantitative measurement of the outcome of policies, such as answering the question of by how much an exchange rate should be devalued or how a country's trade balance would look like if a trade agreement is signed; (2) determining the direction of change in economic variables, such as whether the real exchange rate appreciates or depreciates should a particular policy be adopted; (3) providing evidence that can ignite public debate on certain policy issues, such as advising on whether liberalizing the trade regime in a country increases or lowers wages; and (4) providing evidence on the experiences of different countries and allowing cross country comparisons. When it comes to the research areas of CGE models with a development focus, Devarajan and Robinson (2013a) considered only those applications

focusing on economics, rather than other sciences, and classified these applications into nine major categories for tasks that CGE models are commonly used to achieve. These nine tasks are to: (1) evaluate the adjustment to economic shocks; (2) evaluate the impact of trade reforms; (3) evaluate the impact of changes to public finance and fiscal policies; (4) assess the impact of various policies on poverty and income distribution; (5) assess the impact of agricultural policies and agricultural investments; (6) address education, health and other human development policies; (7) evaluate the impact of labor market policies; (8) evaluate the impact of international trade agreements; and (9) assess the implications of climate change.

After having surveyed the contributions of CGE models to policy analysis worldwide and particularly in developing countries, this paper zooms further in with the objective of providing a detailed review of CGE applications to selected countries and clearly identifies potential future CGE research areas in these countries.

This paper consists of six sections. Following this introductory section, four sections are devoted to reviewing the CGE literature applied to the four countries, with a section for each, starting by Palestine, followed by Israel, the Sudan and Nigeria. Finally, the paper ends by a conclusions section.

2 CGE applications to Palestine

The economy of Palestine has several special characteristics that mainly evolve from the lack of sovereignty and the lack of recognition by other countries as an independent state. The lack of sovereignty is due to the fact that many parts of Palestine are under Israeli occupation for many decades, making Palestine a country with no clear international borders, no independent currency and therefore no sovereign trade and economic policy. This has resulted in a situation where not only the movements of goods and services, but also the movement of people, to and from Palestine is fully under the control of Israel. This means that all taxes on trade, for instance, are collected by Israel on behalf of the Palestinian Authority that somehow tries to govern a divided nation (West Bank and Gaza) that is devastated by concurrent conflicts, Israeli aggressions and a huge dependency on international donations. These characteristics have led all studies (at least those apply CGE models) to focus explicitly on these challenges.

A survey of studies applying CGE models to Palestine shows that these studies were initiated by authors affiliated with the World Bank (Astrup and Dessus, 2001; 2005). These authors were the first to develop a Social Accounting Matrix (SAM) for Palestine, which they used for their model studying the impact of selected trade policy scenarios for Palestine beyond the de facto Paris Protocol. After the World Bank researchers, Missaglia and his coauthors took the lead and conducted several studies evaluating the impact of intifada on the economy of Palestine (de Boer and Missaglia, 2010, 2006; Missaglia and de Boer, 2004; Missaglia and Valensisi, 2014). In addition, Flaig et al. (2013b) examined the impact of relaxing the movement restriction for Palestinian workers in Israel using a CGE model and a 2004 SAM for Israel (Siddig et al., 2011) that includes two Palestinian labor categories.

This collection of CGE studies reflects the perturbing impacts of Palestine's political and economic situations on the Palestinian economy and the requirements of its policy makers and international donors in terms of research-based evidence. The studies are concentrated around: 1) the movement of goods, services and people; 2) the acquisition of international donations, determining their amount and assessing ways of their distribution; and 3) escaping the Paris Protocol and assessing the hypothetical possibilities of applying independent fiscal policies in Palestine with an independent currency. Although these addressed aspects are all relevant and driven by domestic and international needs for evidence, several other issues could be addressed in a CGE framework for Palestine. These include *ex ante* and *ex post* assessments of various policies related to education, health and other services, to income distribution, and to the environment, among others.

In terms of the methodological aspects of CGE applications to Palestine, it is found that both static and dynamic CGE models have been applied to Palestine. In addition, some distinct CGE aspects are also covered in the studies applied to Palestine, such as a detailed nesting of labor categories, the inclusion of the desired, besides actual, consumption for households, and the

depiction of several Palestine-specific rigidities and security related aspects. The studies applied to Palestine, however, show a clear lack of detailed SAMs that depict details on households and production factors, including any categorization according to income, nature of employment, or ethnical, gender or educational backgrounds. Should a detailed SAM for Palestine become available, it is likely that the thematic coverage of CGE studies applied to Palestine would be expanded. The following sections shed light on each of the CGE studies applied to Palestine.

2.1 Trade options for the Palestinian economy beyond the Paris Protocol

To the best of the author's knowledge, the first CGE application to the Palestinian economy was that of Astrup and Dessus (2001), who were the World Bank office representatives in the West Bank. Their paper aimed at quantitatively assessing different options for the future Palestinian trade regime, apart from that governed by the Paris protocol signed in 1994. The authors portray the Paris protocol as a formalization of the de facto customs union with Israel that was in effect since 1967 (Astrup and Dessus, 2001, p. 4). The only addition of the Paris Protocol to the de facto customs union that existed while West Bank and Gaza were totally under Israeli control was giving free access for Palestinian goods to the Israeli market, and vice versa, and placing the policies governing imports from third parties under Israeli control (Astrup and Dessus, 2001, p. 4). The protocol also allowed the Palestinian Authority to set any tariff rates for selected products, mainly consumer goods (list A1 and A2) and equipment goods (list B). In addition to their reflection on the negative consequences of the Paris Protocol's trade regime, their review of previous studies ascribed the poor trade performance of the Palestinian economy since 1993 to imperfect implementation of the Protocol, mainly due to restrictions (security measures applied by Israel) on the movement of goods and people across borders with Israel and within the West Bank and Gaza.

Their CGE model relied on the 1998 supply and use table for Palestine and considered only one representative Palestinian household and 31 economic sectors. It also distinguished four trading partners for Palestine, namely (1) Israel; (2) the countries with which Israel has signed a Free Trade Agreement (EU countries, USA, Canada, The Czech and Slovak republics, Turkey, Hungary, Poland and Slovenia); (3) the group of members of the Arab League, and (4) the rest of the world (ROW). The model applies the small country assumption to Palestine (fixed world import and export prices) with exogenous capital transfers, fixed trade balance, fixed real government deficit and fixed real public expenditures. Investments in the model were assumed to be determined by the availability of savings (Astrup and Dessus, 2001, p. 10).

Four policy scenarios were simulated in the model, namely (1) reducing transaction costs (trade and transport margins) by 15%, exemplifying a relaxation of security controls; (2) elimination of tariffs and purchase taxes on imports from third parties and compensating the loss in the government revenue by a uniform relative increase in VAT rate on domestic and imported

products; (3) cancelation of the purchase tax on imports from Israel; and (4) elimination of tariffs and purchase taxes on imports from all origins.

Results indicate that a reduction in transaction costs improves the Palestinian trade performance and that a departure from the current custom union with Israel may present advantages evolving from dismantling of its related fiscal and trade distortions and the resulting dependency on Israeli security concerns. Hence, a more neutral trade regime with the rest of the world generates gains of specialization, additional welfare for households and lower transaction costs, especially from exports, which would no longer be destined to Israel. The results also suggest that trade liberalization could lead to a strong deflation of the price of investments and an increase in the rate of return to capital, which combined should provide strong incentives for further capital formation in Palestine. This is in addition to increasing real wages that encourage larger labor force participation by the working-age population on the domestic market in Palestine.

Finally the authors wind up their conclusions by stating that any gains created by a possible departure from the current system will mainly depend on the design of the new trade policy as one component that considers the various challenges surrounding the Palestinian economy. Their analysis shows that trade agreements are not necessarily a solution to be envisaged, as they may be confronted with challenges such as the rules of origin.

A few years later the same authors (Astrup and Dessus, 2005) used a recursive dynamic version of their previous CGE model (Astrup and Dessus, 2001) to assess the growth implications of several scenarios related to trade reforms in Palestine. They calibrated their dynamic model to an aggregated version of the 1998 SAM. The SAM considers one representative household; seven economic sectors including agriculture, manufacturing, construction, commerce, transports, private services and public services; two production factors (labor and capital); and two trading partners for Palestine, namely Israel and the Rest of the World (Astrup and Dessus, 2002, p. 16).

Regarding the dynamics of their model, they assumed that traded goods are more capital intensive than non-traded goods, which implies that the demand for capital will be greater if exports have a larger share of GDP. Another Palestine specific consideration was that the majority of investments, such as residential building, are unproductive. Therefore, their model makes a clear distinction between productive and unproductive investments (Astrup and Dessus, 2005, p. 20).[6]

Six scenarios are simulated and examined against the developed baseline: namely, 1) a progressive re-opening of the Israeli labor market; 2) permanent closure of the Israeli labor

[6] Refer to Astrup and Dessus (2002) for the full list of assumptions on the model, data and elasticities including a sensitivity analysis on the choices of elasticities.

market; 3) a progressive re-opening of the Israeli labor market, trade liberalization & VAT reform; 4) permanent closure of the Israeli labor market, trade liberalization & VAT reform; 5) a progressive re-opening of the Israeli labor market and aid increase; and 6) permanent closure of the Israeli labor market, trade liberalization & VAT reform, and aid increase.

Major findings and conclusions of the study suggest the following: 1) the larger the amount of Palestinian workers in Israel (labor exports), the lower the capacity of Palestinian sectors to export goods; 2) the depreciation of the real exchange rate in Palestine that may result from a restricted entrance of Palestinian labor into the Israeli labor market will not prevent income losses for the Palestinian people in the short run; 3) this will not remain the case, however, should the depreciation be accompanied by adopting appropriate trade and fiscal policies, which would then magnify GDP growth; and 4) providing external assistance to Palestine within such settings would be a favorable option with a larger developmental impact than a re-opening of the Israeli labor market to Palestinian workers (Astrup and Dessus, 2005, p. 13).

2.2 Food-for-work versus Cash-for-work in Palestine

Based on data on poverty in Palestine during the post-Intifada period showing that 60% of the Palestinian population was poor in 2002, three times more than it had been in 1999 on the eve of the Intifada, Missaglia and De Boer (2004) stayed away from the hot debates of trade regime regulation, labor flows and investment support in the context of Palestine and rather analyzed the provision of emergency assistance to the Palestinian people.

The study starts by describing the different forms of emergency assistance provided, including budget support, food assistance, cash transfers and employment programs. Then it further divided the employment programs into Food-for-Work (FFW) and Cash-For-Work (CFW). The core objective of study was analyzing these two types of relief policies in order to determine whether the workers participating in an employment program should be paid in food and other essentials or in cash.

A CGE model for the Palestinian economy was constructed and calibrated to a reduced form of the Social Accounting Matrix (SAM) of 1998, which was developed by the World Bank (Astrup and Dessus, 2001). The so called “pre-intifada” SAM aggregated the 31 sectors of the World Bank SAM to 8 sectors. Then a so-called “intifada-shock” was introduced in the model to produce a counterfactual “post-intifada” SAM, which was used for the suggested policy simulations. The counterfactual SAM was produced by shocking several variables in the model, including capital stock, labor income from Israel, donor disbursements, the Palestinians’ propensity to save, government saving, the transfers paid by the Palestinian Authority (PA) to the households and the labor force.[7] One distinctive feature of the CGE model in this study is that it

[7] Refer to Missaglia and De Boer (2004) for more details.

assigned two variables to household consumption of each commodity, namely desired and actual consumptions. This was mainly in order to capture the possible differences among the two employment programs, as FFW may distribute an amount of food that is more or less than the desired amount using unsellable vouchers.

A major scenario of the study is to simulate the disbursement of US$ 375 million of emergency aid by the PA as a uniform labor subsidy to each sector in the economy. This can be formulated in two ways: (1) FFW that gives household unsellable vouchers and (2) CFW, which gives the subsidy in cash. Results show that the two programs had similar outcomes because the food aid was not too much and the actual consumption was equal to the desired one, i.e. the pre-intifada food consumption was not restored.

The authors also considered another two experiments, where the first had a FFW program in which donors partly paid world food producers with the remaining part paid by Palestinian importers and the PA again provided its uniform labor subsidy to each sector. This led the domestic price of food to fall under the FFW due to the flow of cheap food from abroad, which even made the unemployed who are out of the scope of relief aid better off and reduced real PA revenues, whereas under CFW they remained almost unchanged.

The authors ultimately rejected the FFW program based on the findings of their first two experiments and preferred a CFW. Therefore, they went further and simulated another experiment that applied a discriminative subsidy disbursement by the PA. Sectors were divided into labor-intensive and consumption-intensive. Accordingly, the subsidy was given once to each sector alone in the form of a shock, representing an employment-oriented approach in the former and a welfare-oriented approach in the latter. The final conclusion preferred the employment-oriented approach (subsidizing the most labor-intensive sectors) to the welfare-oriented approach, where the subsidized sectors produce those goods that dominate the consumption basket.

2.3 Estimation of the economic consequences of the Intifada

The international community was in a hard need for macroeconomic estimates of the Palestinian economy after the Intifada in order to assess interventions. The major players were the World Bank (WB) and the International Monitory Fund (IMF), providing their estimates using a dynamic CGE model and a simple macro-founded income-expenditure model, respectively. According to Boer and Missaglia (2006), the hard hit on the already fragile economy of Palestine of conflicts during 2000 - 2002 was not presented with consensus in terms of the extent and the order of magnitude by which the economy suffered. This was evidenced in the huge differences between the estimates of the WB and those of the IMF, e.g. the Gross National Income (GNI)

estimated by the WB in 2002 was 25% less than that of the IMF (de Boer and Missaglia, 2006, p. 99).[8] The authors found the differences relevant not only for understanding the economic consequences of the Intifada, but also for determining the size of the needed intervention. The study used a CGE model calibrated to the WB 1998 SAM as an alternative option to provide estimates of the economic consequences of the Intifada.

This study built on the authors' previous study on the same context (Missaglia and de Boer, 2004), especially in terms of methodology. Hence the same model and a similar approach to updating the SAM and producing a counterfactual post-intifada SAM were applied.[9] The main task conducted by the study was to use this model to estimate the same macroeconomic indicators as the WB and the IMF. The authors introduced the intifada shock, and because their model produced only nominal macroeconomic estimates such as GDP, they derived the real indicators by deflating each demand component using mainly the CPI (de Boer and Missaglia, 2006, p. 106). Finally, the authors confirmed through comparisons provided in their study that their estimations were closer to those of the IMF (based on a simple macro-founded income-expenditure model) and that their developed data (the counterfactual post-intifada SAM) can be profitably used to simulate various policies relevant to the Palestinian economy at that time, for instance the impact of international interventions.

The same authors repeated their comparison exercise in 2010 after more consensus results were published by the WB and the IMF in 2007 (de Boer and Missaglia, 2010). The authors compared the values predicted by three models, namely the WB dynamic CGE model, the IMF macro-founded income-expenditure model and the DBM (de Boer and Missaglia, 2006) static CGE model to the 'actual' indicators of the *ex post* consensus estimates of the IMF and WB of 2007. They concluded that the estimates of the static CGE model are closer to the true outcomes than those obtained with the two alternative models because the static CGE accounted for the Intifada shock.

2.4 Relaxing the Israeli restrictions on the movement of Palestinian workers

The consequences of the second Intifada on the Palestinian economy in the CGE context are mainly addressed using a CGE model for Palestine. However, other authors tried to tackle the effects on the West Bank economy indirectly (Flaig et al., 2013b). The study focused on Palestinian workers crossing borders on a daily basis into Israel mostly and assessed impacts from a scenario of reduced restrictions on their movement into Israel. Workers' remittances are

[8] Refer to the Table in page 99 of (de Boer and Missaglia, 2006, p. 99) for full comparison between the WB and IMF assessments.

[9] Some detailed are provided in section 2.2 of this paper, while additional details can be obtained from (Missaglia and de Boer, 2004).

important for the West Bank's economy, especially before the Intifada when the share of Palestinians working in Israel was about 23% of employed Palestinians. This share is politically sensitive and technically governed by a quota that determines the number of foreigners (including non-Palestinians) who are allowed to work in Israel. Flaig et al. (2013b) assessed the impact of increasing the quota of Palestinian workers in Israel from its current level (50 thousand) to its pre-Intifada level (114 thousand) on total remittances accruing to the West Bank economy.

The study applied a single country CGE model adapted to a 2004 SAM of Israel (Siddig et al., 2011). The model applied a five-level nesting structure of production, in which a Leontief function is applied at the top (value added aggregate vs. intermediate input aggregate) and a CES function is applied elsewhere in the nest. The Palestinian workers appear at the bottom of the nest, substituted with other foreigners (mainly from Asian countries) to constitute the total non-Israeli workers. The total non-Israeli workers are then substituted with Israeli workers in the fourth level of the nest to constitute total unskilled labor. The third level substitutes unskilled labor with skilled labor to constitute total labor, which is substituted with land and capital in the second level of the nest to constitute total value added (Flaig et al., 2013b, p. 146).

Results indicated that although the wages of Palestinians working in Israel decline by 17% in response to an additional supply of workers, the overall labor income to Palestinian workers increases by 84%, which is expected to raise the contribution of remittances to the West Bank's GDP of 2004 from 14% to 26%. This also reduces unemployment in the West Bank and, of course, increases income (Flaig et al., 2013b, p. 149). The authors further mentioned that such an inflow of remittances may lead to an appreciating domestic currency in real terms (Dutch disease) and therefore offset any potential benefits from increased remittances, a situation that cannot be addressed without a separate model for the West Bank and, preferably, a multi-region CGE model for the West Bank and Israel with endogenous Palestinian labor supply decisions.[10]

2.5 A reassessment of contemporary trade policy options in Palestine

Building on the fact that CGE models that are commonly applied to fiscal and trade policies are driven by closure rules and causality assumptions adopted by the modeler (Taylor and von Arnim, 2006), Missaglia and Valensisi (2014) argue that the Palestinian economy has a couple of special settings that must be considered when applying a CGE model. Missaglia and Valensisi (2014) stress for instance, the prevalence of unemployment in a conflict-torn economy to be particularly counter to the theoretical assumptions applied in standard CGE models. Accordingly, they claim to enhance the consistency between the modelling assumptions and the uniqueness of the Palestinian economy and to assess the extent to which results obtained from

[10] For additional details, refer to Flaig et al. (2013b).

previous simulations exercises in the context of Palestine were robust under alternative macro closures. These issues are incorporated in a CGE macro-model for the Palestinian economy that considers the institutional arrangements enshrined in the Paris Protocol, the asymmetric integration of the economy with Israel and the influence of the recurrent conflicts on the economy.

Their modifications of the models of Astrup and Dessus (2001; 2005) include (1) an adoption of a Leontief production function for the substitution between production factors to rule out factor substitutions and allow for incremental capital share changes[11] and a mark-up pricing rule with the mark-up rate depending parametrically on the degree of competition, hence, imperfect competition prevails; (2) a replacement of the Armington assumption (Armington, 1969) by a different conceptual approach for both imports and exports. For imports, a log-linear demand function was adopted to relate the imports of final goods to the real output and relative price of domestically produced and imported goods, while the unitary income elasticity of import was avoided in a CES setting that substitutes demand for imported goods from Israel and the rest of the world by applying a predetermined elasticity value. For exports, the CET was replaced by ad hoc export functions that capture sales of Palestinian goods to Israel or the rest of the world (using two substitution elasticities for exports to the two regions) and the relevant real exchange rates; (3) a consideration of fiscal policy specificity in Palestine. The authors argue that it is hard to assume that public expenditures in Palestine are predetermined and public receipts (mainly from foreign donors) adjust endogenously to clear the government fiscal account. Another fiscal aspect is that, according to the Paris Protocol, VAT and tariffs, which represent a large share in public receipts, are collected by Israel and are subject to the political environment. Hence, Missaglia and Valensisi (2014) assumed that tax revenues directly collected by the Palestinian Authority are endogenous, while the budget deficit is exogenous to depict its dependency on revenues collected by Israel and those coming from international donors; and (4) different assumption related to the balance of payment that assumes endogenous financial flows from the rest of the world to Palestinian households. By this, the authors tended to capture the effect of large capital inflows transiting through the financial account, while acknowledging the magnitude of remittances and official donor assistance inflows to Palestine and the exogeneity of the latter. It also considered the overlapping use of multiple currencies, namely the US$, the Jordanian Dinar and the NIS. The modified model was then calibrated to a simplified macro-SAM for Palestine with the required parameters being taken from the literature.

Three different experiments related to trade liberalization were simulated: (1) elimination of tariffs and purchase taxes on imports from the rest of the world; (2) elimination of tariffs and

[11] This is to escape the assumption of fixed technical coefficients in static framework and allow for parametric shifts in the coefficients that are captured in the longer-term horizon by accounting for factors substitution and efficiency gains. This approach follows the post-Keynesian economic theory (Missaglia and Valensisi, 2014, p. 10).

purchase taxes on imports from Israel; and (3) elimination of tariffs and purchase taxes on imports from all origins. Each of the three experiments was run using two different closure rules. The first closure fixed government real expenditures and net position at the base and allowed tax revenue to adjust, while the second closure (authors preferred) fixed government savings to the base level and applied the pre-determined tax-rates.

Major findings of the study are that trade liberalization may neither have huge developmental nor growth implications on the economy of Palestine, as the authors found the economy to be relatively open to international trade (Missaglia and Valensisi, 2014, p. 15). Nevertheless, the consequent public expenditure losses indicate that trade liberalization may turn out to be slightly contractionary. The authors suggest that these negative consequences of liberalization policies can only be overcome by combining such policies with complete transfer of taxes and duties collected by Israel for Palestine. The authors also identified some areas for future development of CGE research on Palestine, including the incorporation of detailed productive structure, disaggregated accounts for production factors (especially skilled and unskilled workers) and possibly a clear distinction between residential and non-residential investments.

3 CGE applications to Israel

CGE applications to Israel started in 2008 by the research of Palatnik and Shechter (2010a, 2010b, 2008). Together with her coauthor, Palatnik assessed the implications of several experiments related to carbon emissions reduction for the Israeli economy. CGE studies focusing on the Israeli economy are a good example of the overall concentration of CGE studies according to authors and themes in each country. It is noted that the CGE model and SAM developed for Israel by Palatnik and Shechter (2008) were meant to address environmental policies and, more specifically, were related to carbon emissions, as demonstrated by their detailed structure and nest of the energy sector. Therefore, the three CGE studies published between 2008 and 2010 address quite connected policy questions.

After the work of Palatnik and coauthor, and contrary to their thematic concentration, five CGE studies in the context of Israel were published during 2013 and 2014. The first within this series was Flaig et al. (2013c) on the implications for domestic workers, households and the economy at large of a less restrictive Israeli policy towards Palestinian workers. The second is that of Flaig et al. (2013a) on domestic and trade policies of the dairy and milk sectors. Subsequently, Siddig and Grethe (2014b) analyzed the linkages between econometric price transmission analysis and CGE models and Luckmann et al. (2014) modeled the complex nature of the Israeli water sector. Finally, (Siddig and Grethe, 2014a) study the impacts of new natural gas discoveries in Israel on the economy and its linkages to an agreement with Egypt on the imports of gas.

The second series of CGE applications to Israel (i.e. those published in 2013 and 2014) were motivated by the availability of a detailed SAM for Israel with various activities, household groups, production factors and tax accounts (Siddig et al., 2011). The thematic focus of these five studies is quite diverse and the studies provided noticeable methodological contributions in the field of CGE modeling. Themes range from labor market polices, domestic trade policies, international price movements, to water and energy. Methodological contributions include: 1) the introduction of a detailed labor nesting structure; 2) the inclusion of imperfect competition and Tariff Rate Quotas (TRQs); 3) the development of the linkages between econometrics and CGE modeling with respect to the price pass-through; and 4) the depiction of different water types and uses in CGE models. The eight CGE applications to Israel are comprehensively covered in the subsequent sections.

3.1 CO2 emission reduction and revenue recycling

In their literature survey on the impacts of global warming and GHG emissions in Israel, Palatnik and Shechter (2008) realized that GHG carbon dioxide emission is largely due to the combustion of carbon-rich fossil fuels, which is the main source of energy. Energy in turn is employed as an input to virtually every activity in the economy. This implies that any taxes or restrictions on CO2 emissions increase energy prices, reduce energy use, and hence decrease overall economic

output and welfare. However, their literature review showed that no economy wide tools were applied to depict these economy wide implications. Therefore, they constructed a CGE model with a detailed structure of the energy flows and calibrated it to a 1995 SAM for Israel in order to address GHG emission mitigation scenarios[12]. The model is a static CGE model for an open small economy calibrated to a SAM with 18 commodities, of which 4 are for energy, while multiple commodities are possibly produced by each activity. The SAM has one account for each institution including the government and households, one investment account and one foreign account.

A Leontief function was applied for production on the top level where primary factors and energy inputs are substitutable with non-energy inputs. In the second level of the nest, and up to the fifth level, a CES function was applied. Capital and energy are substitutable with labor in the second level, capital is substitutable with energy in the third, fossil fuel is substitutable with electricity in the fourth, and coal is substitutable with oil in the fifth level. Finally, a sixth level is also included in the nest to substitute crude and refined oils using a Leontief function that, in effect, allows no substitutability. To capture the employment double-dividend hypotheses, the model was modified to consider endogenous labor supply and involuntary unemployment. All elasticity values were adopted from various literature sources.

The model and its data were setup to answer the following research questions: (1) what are the suitable carbon energy tax and tradable permit prices that lead Israel to meet its Kyoto target of energy-related emissions of CO2; (2) how would such policies impact the Israeli economy and its welfare levels; and (3) would an (employment) double-dividend be possible for the Israeli economy?

Commodity-specific emission coefficients were calculated using data on CO2 emissions by sector, which were used to calculate the economy's CO2 emissions in the base by multiplying them by each sector demand of fossil fuel (Palatnik and Shechter, 2008, p. 15).

Under the settings of a fixed labor supply, results of an environmental policy that proportionally cuts taxes indicated that significant CO2 emission reductions can be achieved at modest economic cost, but that no double-dividend could be discerned. Under the second settings where labor market imperfections were introduced in order to address the employment double-dividend, results showed that an employment double-dividend is possible particularly when higher substitutability is considered between the composite energy input and labor and capital. Furthermore, results of various sensitivity analyses confirm that the higher the substitution possibilities within the production functions, the lower the welfare costs associated with emission reduction policies.

[12] According to Palatnik and Shechter (2008), the 1995 SAM was the first to be built for the Israeli economy.

Finally, the authors hint at future research addressing the inclusion of renewable energy within the energy nest; introducing imperfect competition, which is especially relevant to the Israeli electricity sector; further disaggregating the household account to capture the distributional implications; and including greenhouse gases other than carbon dioxide.

Similar exercises were undertaken by Palatnik and Shechter (2010a) and Palatnik and Shechter (2010b) with slightly more focus on recycling the emission tax revenues to reduce taxes on labor and encourage employment. The studies applied the same CGE model for Israel and the same SAM and parameters (Palatnik and Shechter, 2010a, p. 419, 2010b, p. 27). These were mainly motivated by the intensive debate following the Copenhagen Accord, where the Israeli minister of Environmental Protection declared that his government is committed to reduce CO2 emissions by 20% by 2020 (Palatnik and Shechter, 2010a, p. 912). It was also motivated by the high tax rates applied to labor and the high unemployment rate in Israel (5.9% in August 2008 and 8.4 % in May 2009). Accordingly, the two studies sought to provide quantitatively supported policy recommendations to the Israeli government on options of introducing a CO2 emission tax without exacerbating unemployment and reducing welfare.

The simulated emission reductions were found to cause major reductions in domestic energy-intensive production, leading to a large reduction in employment, especially in energy-intensive sectors. At the macro level, GDP falls by less than 1% and welfare slightly declines, even at relatively high levels of carbon tax (Palatnik and Shechter, 2010b, p. 36). However, the recycling of carbon tax revenues in the form of labor tax reductions were found to increase labor demand by non-energy-intensive sectors and reduce the overall level of unemployment. On the demand side, consumption patterns vary depending on changes in relative prices, with a clear shift from high emission to low emission energy sources, and generally from energy commodities to non-energy commodities. These demand changes and changes in input costs also affect the supply side, where the production of sectors with high CO2 emissions relative to those with low emissions declines (Palatnik and Shechter, 2010b, p. 36).

These findings generally coincide with those of Palatnik and Shechter (2008) and further confirm that an employment double-dividend is a viable option in Israel, particularly under the assumption of high substitutability between the energy input and labor and capital (Palatnik and Shechter, 2010a, p. 920).

3.2 Costs and benefits of relaxing restrictions on Palestinian workers in Israel

Palestinians have a long history of crossing borders legally and illegally to work in Israel, mainly for low-skilled jobs in agriculture and construction. This, however, started to considerably change after the second Intifada in 2000 when border restrictions were severely increased and a quota system with various eligibility conditions was introduced. From a Palestinian perspective, it can be easily concluded that this increases unemployment and reduces income from

remittances, which is covered in section 2.4 of this study. What was missing in the CGE literature applied to this region is the other side of the coin that assesses the implications of such a border policy on the Israeli economy and households.

This gap was addressed by Flaig et al. (2013b), applying a single country CGE model for Israel calibrated to a 2004 SAM. The applied SAM (Siddig et al., 2011) includes two separate categories for Palestinians working in Israel, namely those who entered according to the quota system and those who crossed the borders illegally, in addition to other foreigners and, of course, plenty of Israeli labor categories. In addition, the applied CGE model has a five-level nesting production function in which Palestinian workers are substitutes with other foreigners at the bottom of the nest to constitute the overall foreign labor category, which in turn substitutes with unskilled Israeli workers in the fourth level of the nest. Therefore, any policy that involves increasing the number of Palestinian or other foreign workers is expected to affect the employment of Israeli unskilled workers, which was the original reason for Israel to impose quotas on the employment of foreigners.

A partial liberalization of the labor market in Israel was simulated. The simulation particularly increases the quota of Palestinians allowed to work in Israel from its current level of 50 thousand to 114 thousand (pre-Intifada level). Results of the simulation show an increase in overall domestic production and a slight enhancement in the economic growth of Israel, should the labor market remain segmented (Flaig et al., 2013b, p. 148). From a distributional perspective, the relaxation of restrictions was found to widen the income gap between poor and rich households in Israel, which results from higher increases in factor returns to rich households relative to poor households. Nevertheless, despite these negative distributional effects with respect to factor incomes, overall welfare gains were recorded for all households groups in Israel, driven by the greater reductions in the cost of living for poorer households. The latter, of course, was driven by increasing domestic production and imports[13].

3.3 Contemporary and future policy prospective of the dairy industry in Israel

Prices of dairy products in Israel witnessed considerable increases in 2011, leading to consumer unrest, protests and boycotts against selected dairy producers and products in the summer of 2011. In reality, both the production of raw milk and dairy processing in Israel are not competitive, as production quotas and administered prices are maintained for raw milk, while dairy processing is dominated by only three large firms (Tnuva supplies two thirds of domestic demand, and Tara and Strauss almost fully supply the remaining demand). This remained the same for a number of years, however the consumer protests of 2011 forced the government to form a special committee (the Kedmi Committee) to assess possible ways of dealing with the

[13] For additional details, refer to Flaig et al. (2013b).

situation (Flaig et al., 2013a, p. 839). The committee mainly considered liberalizing markets for both dairy products and domestic milk production. This led to partial openness towards importing dairy products at least for hard cheese, but was expected to extend to other products. For domestic production, the committee recommended publicly funding the construction of additional milk processing plants to increase competition among milk processors.

The study of Flaig et al. (2013a) starts from the policy alternatives available to the Kedmi Committee and further assesses the implications they may have on the economy of Israel at large. In their literature review, the authors concluded that such problems could be addressed best by using CGE models that embody Imperfect Competition (IC). However, the authors found such applications to be very limited, due to the existing theoretical and practical difficulties related to the determination of the optimal mark-up and the demanded quantities (Flaig et al., 2013a, p. 840). In their study, however, IC is reflected in their included quantity data and the price mark-up is estimated from price data. Hence, their model incorporates two major distinctive features, namely tariff rate quotas (TRQs) and IC.

For the TRQs, the model adopts a modified version of the mixed-complementary-problem approach of van der Mensbrugghe (2003), in which licenses to importers are assumed to be distributed by the government via auctions and, therefore, the quota premium is specified as government income. This approach, however, is not applied in Israel, where the government allocates import licenses for in-quota imports according to a first-come, first-served system at no costs. This feature was incorporated in the modelling of TRQs in this study's CGE model (Flaig et al., 2013a, p. 842). For IC, the approach of Francois and Reinert (1997) was adopted.

Four scenarios were simulated as follows: (1) a base scenario as a reference that reflects the characteristics of the Israeli milk and dairy markets with a binding TRQ for milk and dairy products, quota rents on imports of milk and dairy products, an administered domestic producer price for milk, and an oligopoly market for dairy products with a predetermined price-cost mark-up; (2) a scenario abolishing the administered price for milk and breaking up the dairy oligopoly, while maintaining the border protection for milk and dairy products; (3) one abolishing the TRQs on raw milk and dairy products and converting them into a tariff system; and (4) one fully liberalizing the trade regime by setting tariff rates to the applied in-quota tariff of 0.1% for milk and 0.6% for dairy products, eliminating the oligopolistic mark-up and freeing the price of raw milk.

Domestically liberalizing the two sectors reduces the consumer price of dairy, increases dairy demand and stimulates dairy production. The latter, in turn, increases the demand for milk by the domestic dairy industry. No relevant changes were recorded in producer prices, which confirms that no welfare losses are associated with the elimination of the oligopoly markup (Flaig et al., 2013a, p. 850). The simultaneous elimination of both the oligopoly and the production quota for milk results in increases in the demand and production of milk.

Finally, the international trade liberalization of the two sectors shows different outcomes given the high nominal protection coefficient of 1.6 for dairy products in Israel. Hence, dairy imports, of which only about 30% could be imported, increase markedly, leading to a decline in the domestic production of 13% under this scenario. In their policy recommendations, the authors point out that the three policy options lead the consumer prices of dairy and milk to decline and would obviously satisfy the needs of the boycotting consumers. Nevertheless, if a selection from the policies is to be made, then it is to be considered that the aggregate positive effects on households and those on the macro economy would be larger under the international trade liberalization scenario. This being said, the latter scenario would leave no room for self-sufficiency agendas to be accomplished within these sectors (Flaig et al., 2013a, p. 850).

3.4 International price transmission in CGE models

This is study of a more methodological nature, combined with a case study for Israel. The motivation of the paper is the concentration of the literature that addresses the transmission of world prices to domestic markets on econometric time-series analysis. These methods, despite being powerful in describing and forecasting price relationships through time, are unable to show the impact of a certain level of price transmission on the different actors of the economy. The latter is a typical characteristic that is imbedded in each CGE model with detailed sectoral disaggregation. On the other hand, despite their ability to capture sectoral, distributional, and economy-wide effects of world price changes, in their standard specification CGE models are typically not calibrated to reflect an empirically observed degree of price transmission. Therefore, the authors sought ways to integrate the two methods that are needed to address issues such as effects of recent food price increases (Siddig and Grethe, 2014b, p. 12). The objectives of the study of Siddig and Grethe (2014) were to analyze possible options for calibrating CGE models to a given degree of price transmission, e.g. being estimated based on econometric methods.

The authors hypothesize seven different determinants being influential for the pass-through of international prices to domestic markets in CGE models based on general economic and trade theories. The determinants are: (1) the trade share of the commodity (including imports and/or exports) relative to domestic production; (2) the value share of the commodity in the domestic economy; (3) the share of the sector/commodity in domestic use of production factors; (4) the degree of factor mobility among sectors; (5) trade elasticities (CES and CET); (6) elasticities of substitution among value added and intermediate inputs; and (7) the applied exchange rate policy.

The study uses a single country comparative static CGE model of McDonald and Thierfelder (2009) together with a detailed Israeli 2004 SAM (Siddig et al., 2011) as a laboratory to run a series of sensitivity analyses with the aim of validating the a priori assumptions about the determinants of pass-through. The model applied Stone-Geary utility functions for the utility

maximizing behavior of households, while domestic versus imported goods selection was governed by a CES function. The small country assumption applied to the selected food sectors of the study's simulations (wheat, other cereals, and other crops) in the Israeli economy. Hence, world prices of imports and exports were fixed. A two-stage production function was applied with CES on the top level and throughout the value added nest, while a Leontief function comprised different intermediate input commodities. Model closures were set to reflect the characteristics of the Israeli economy as much as possible at the beginning and were changed consecutively during the sensitivity analyses.[14]

The study concluded that the pass-through of international prices in domestic markets within CGE models can be controlled through specific configurations of closure rules and elasticities. It was concluded that: (1) the higher the trade share of the commodity, the higher the transmission of the world market price to the domestic market and the bigger the implications on the economy at large; (2) increasing export prices together with low CET elasticities and high production elasticities may even result in negative effects on domestic consumer prices; (3) the higher the factor mobility, the lower the price transmission; (4) the higher the trade elasticities, the higher the price transmission; (5) the higher the production elasticities (top and second level), the less is the price transmission; and (6) the pass-through of an increasing world price would be higher under a fixed exchange rate regime compared to a flexible one, if the domestic currency appreciates due to the world market price shock (Siddig and Grethe, 2014b, p. 21).

3.5 Modeling the complex nature of the water sector in Israel

The importance of managing different uses of water and addressing its scarcity is growing, driven by a growing world population and other factors. Water is used in most economic activities in every economy and its allocation across different uses is often a complex problem involving many agents. Accordingly, it is unsurprising that CGE models, although still underdeveloped to include and model water aspects, have proven useful to address the problem of water allocation (Luckmann et al., 2014).

The standard methods of evaluating water-related decisions, such as water use, provision and investments, are all variants of cost-benefit analyses. This usually requires detailed data on the costs (e.g. opportunity costs of resource-based investments) and benefits of each decision. Therefore, CGE models have the potential to aid such decisions, especially those related to water use of human agents and to what extent water pricing and policies may influence them. The use of CGE models can also be extended to capture the economic costs associated with different water management policies, as well as environmental implications (Luckmann et al., 2014, p. 3889).

[14] Refer to Siddig et al. (2011) for more details on the model closure and assumptions.

Acknowledging the potential of CGE applications to water policies and the limited development of such type of models, Luckmann et al. (2014) developed and applied an integrated water-focused CGE model (STAGE_W). The model allows for multiple types and uses of water, in addition to including the novelties of allowing the representation of reclaiming wastewater and utilizing brackish groundwater as independent activities in the model with specific cost structures. The developed model permits using a range of user-defined production technologies, different types of water resources and a range of adjustable tax instruments to suit individual economies. The STAGE_W model (Luckmann and McDonald, 2014) allows for producing water of the same quality by multiple activities, while the different water qualities represent inputs in the production functions of other sectors and can be consumed by households (Luckmann et al., 2014, p. 3877). STAGE_W is an extension of the STAGE CGE model (McDonald, 2007), which is a SAM-based, single country, and comparative static CGE model.

The extensions of the STAGE model include: (1) modification of the production system to allow for producing homogeneous commodities by multiple activities; (2) the imposition of policy instruments (taxes/subsidies) and resource/input constraints; (3) the inclusion of seven types of water, of which three are natural resources (freshwater, seawater, and brackish groundwater), one is wastewater, and three are water commodities produced from these four, namely potable water, brackish water and reclaimed water from wastewater; and (4) an extended database based on a 2004 SAM for Israel (Siddig et al., 2011). The production function has four levels, with the top level substituting value added and intermediate inputs. The water resources and commodities are all moved to the value added nest, where labor, capital and the water/land aggregate are substitutable. In the third nest, water and land are substitutable, while in the fourth level the seven different water commodities and natural resources are substitutable. Intermediate inputs are combined by a Leontief function and water activities likewise use Leontief functions throughout their nesting structures. The non-water activities apply CES functions throughout the nests except for intermediate inputs substitution (Luckmann et al., 2014, p. 3879)[15].

As a case study, the model was applied to Israel to address the current water policy debates focusing on the viability of increasing desalination capacity, the efficiency of investing in water saving technologies and water recycling. In this application, a reduction in the available freshwater in Israel is simulated under two different scenarios, with the first assuming no additional development in desalination and the second allowing for the expansion of the desalination capacity.

Results indicate that even huge reductions in water resources would have a relatively small impact at the macroeconomic level. Under the assumption of possible desalination capacity

[15] For more details, refer to Luckmann et al. (2014).

expansion, the total consumption of potable water declines by less than 2% because freshwater resources can be substituted by desalinated water. If no desalination expansion is allowed, the output of several activities declines by no more than 1%, although their water consumption declines by more than 60%. Hence, the overall impact on the economy is accordingly small. Reducing substitution elasticities in the production nests, however, is found to yield higher impacts. For instance, 50% lower elasticity values lead to a decline in the output of irrigated agriculture of up to 14%, a fall in real GDP by 0.8% and a decline in the EV by 2.3% of base household income. One reason that the macroeconomic effects of the two scenarios are quite similar even though a much lower effect was expected under the expandable desalination capacity is that the cost of desalination is very high relative the provision of potable water from natural freshwater. Hence, the government is heavily subsidizing desalination and its expansion implies additional distortions in the economy.

In their outlook, the authors foresee several opportunities to enrich the insights provided by their model to further aid water-related policymaking. They suggest that the model can be extended to rely less on economic data and, instead, be connected to engineering and scientific knowledge. Such information could include the existing substitution possibilities across different inputs, input requirements of new production technologies, environmental impacts of different water resource decisions and how they might feedback into the system and hydrological information to understand the physical interconnectedness of water systems (Luckmann et al., 2014, p. 3890).

3.6 Offshore discoveries and import uncertainty of natural gas

Until March 2013, Israel imported 40% of its domestically consumed natural gas from Egypt. Until recently, Israel was considered an energy island and Egypt was the only supplier of natural gas. Nevertheless, gas was imported from Egypt at a relatively lower price compared to gas prices in the region, according to an agreement between the two countries. This preferential treatment of Israel by Egypt has created public discontent in Egypt, particularly after the 2011 revolution, as demonstrated by repeated sabotages to the pipelines. In March 2013, the Tamar field of natural gas came into production, while other discoveries including the Dalit and Leviathan fields are expected to start production in 2 to 3 years. The production of these fields together suffices the Israeli natural gas demand and transforms the country into an exporter. This implies that Egyptian gas might no longer remain relevant. Alternatively, Israel may decide to continue importing cheap Egyptian gas and exporting its own additional production to other destinations, such as Europe and Jordan.

Siddig and Grethe (2014a) quantitatively investigated the effects of these two options on the Israeli economy. Their study applied the MyGTAP[16] model of Walmsley and Minor (2012) and the standard GTAP model of Hertel (1997), together with the GTAP database (Version 8.1) that includes the Israeli Input Output Table (IOT) (Siddig et al., 2012) and a 2004 SAM for Israel (Siddig et al., 2011). The relevance of the SAM here is that it provided the details to further disaggregate the standard GTAP households and production factors, among other transactions. Three experiments were examined in the study, including (1) increasing the price paid by Israel for importing the Egyptian gas to equalize it to the average world market price; (2) keeping the preferential imports price in place and doubling the domestic gas production in Israel to reflect the production of new fields; and (3) combining the two experiments in one simultaneously solved experiment.

Results of the first scenario, which increased the price of imported natural gas, increased the domestic gas price by 50%, decreased demand for imported gas by 80% and thus reduced the production of gas-dependent sectors. At the macro level, it reduced total absorption and forced real GDP to slightly decline by 0.05%. Poorer households were harder hit by the shock relative to richer households. Ethnically non-Jewish households were more negatively affected than Jewish households, with poor non-Jewish households being the most negatively affected in relative terms. The second experiment, which doubled the domestic production of gas in Israel, increased GDP, welfare and domestic absorption. Here the economy was found to benefit from the increasing domestic production without increases in the price of imported gas. Hence income to households increased, with poorer households benefiting the most due to their higher income gains and lower CPI. Based on these results, the authors recommend the continuation of the gas importation agreement between Egypt and Israel as beneficial for the Israeli economy, even if its domestic gas fields come into production. The authors argued that these conclusions coincide with viewpoints in Israel that the agreement with Egypt as well tightens political relations and preserves peace (Siddig and Grethe, 2014a).

The authors highlighted some weaknesses in their approach and paved the way for further developments and improvements. They found their experiments to partially capture the positive effects of gas discoveries, especially revenues from potential exports. More specifically, they pointed out the following future considerations: (1) the prevailing Leontief structure (e.g. in the electricity and transportation sectors) limited any possibility of replacing coal and refined oil by gas in electricity generation and transportation; (2) gas production was only simulated to increase by 100% even though it is foreseen to increase much higher in the medium to long runs; and (3)

[16] Additional details on the differences between GTAP and MyGTAP models are provided in section 5.4. More details can be found in Siddig and Grethe (2014a). For the entire documentation of MyGTAP model, refer to (Walmsley and Minor, 2013).

the expected reduction in the risks associated with energy supply shortages due to the increasing domestic production are not captured within this approach (Siddig and Grethe, 2014a).

4 CGE applications to the Sudan

A literature review shows that seven CGE studies have been applied to the Sudanese economy, with publications starting from 1994. The 1994 study assessed the economic consequences of introducing more energy-efficient wood burning stoves with the objective of reducing the environmental impact of clear-cutting trees for firewood (Dufournaud et al., 1994). An extended review of this study is provided in the first section of this chapter. The second CGE application to the Sudan was that of Elbushra et al. (2010), which together with a study published in 2012 (Siddig, 2012), was driven by the instability of the Sudanese currency during the last ten years. Hence, these studies assess the implications of various exchange rate policies for the economy. These two studies are covered with more detail in the second section of this chapter.

Although CGE applications to the Sudanese economy started earlier than any CGE application in the four countries considered in this paper, there was a gap of 16 years before the second CGE application was published, which is the study of Elbushra et al. (2010). This can be partially explained by the international isolation that the country has suffered due to USA sanctions since 1994 and UN sanctions since 2003. Besides their economic implications, the sanctions also limited many possibilities of research collaboration with Sudanese universities and research institutions that are needed to enhance the capacities of domestic researchers. The impact of economic sanctions on the Sudanese economy is covered with more detail in the third section of this chapter, and the full-text of the underlying article on the topic is provided in **Error! eference source not found.** (Siddig, 2011).

The economy of the Sudan is historically known to be an agricultural-based economy with the sector contributing not less than one third of the GDP through time. However, several empirical studies show the productivity of this sector to be low, especially that of its traditional farming system. The traditional agricultural sector is an important sector in the Sudan because it covers the majority of the cultivated land. Therefore, enhancing agricultural productivity has the potential of improving the country's overall economic performance. Against this background, Siddig and Babiker (2012) studied the impact of improving the efficiency of the traditional agricultural sector on the economy with and without a liberalized trade regime. More details on their motivation, methodology and findings are provided in the fourth section of this chapter. The fifth section of this chapter reviews a study on the linkages between rainfall variability and food supply in the Sudan (Sassi and Cardaci, 2013), while the last section (4.6) addresses the implications of the division of the Sudan (Siddig, 2014).

It is to be noticed that no CGE application to the Sudan has had a methodological focus and contribution other than that of Dufournaud et al. (1994), which is one of the early studies that introduced technical efficiency issues in CGE models and implemented such a framework for energy efficiency in a developing country. This could be linked to the lack of capacity in CGE modeling and database development partially caused by the international isolation of the

domestic research institutions. The first relatively detailed SAM for Sudan was developed in 2009, but lacks disaggregated households and production factor accounts and depended on no officially provided input/output or supply and use tables (Siddig, 2009). With its huge agricultural potential, agro-ecological diversity and income inequality, the country is expected to attract many CGE applications should a reliable and disaggregated SAM become available. The six CGE applications to the Sudan are reviewed in the following sections, starting with the study focusing on the environmental aspects of firewood use in the Sudan.

4.1 A policy designed to reduce the household consumption of wood

In the first ever CGE work applied to the Sudan, Dufournaud et al. (1994) used an applied general equilibrium model to examine the economic consequences of a policy that was proposed to reduce the consumption of firewood. The study rests its motivation on the fact that the Sudan, among many other countries in the Sahel of Africa, was facing urgent environmental problems caused partially by the c1ear-cutting of trees for firewood. The authors based their work on several empirical studies that examined approaches to reduce the household consumption of firewood, one of which was the introduction of more efficient wood burning stoves. Their study was one of the early studies applying a CGE framework to technical efficiency issues globally and linking such a framework to energy efficiency in a developing country (Dufournaud et al., 1994, p. 68).

The idea of Dufournaud et al. (1994) was to quantitatively clarify that the effects of policies commonly designed to curtail households' consumption of wood and biomass with the objective of addressing the environmental crisis can be reduced by the rational adjustments of consumers in response to changes in relative prices of consumption goods, including the energy itself. Therefore, the authors started with a comprehensive review of relevant empirical literature and showed that several studies concluded that energy policies have led to a saving of wood at less than what was expected (Dufournaud et al., 1994, p. 69).

The authors identified and included two distinctive approaches for integrating household utility implications of firewood collection and consumption. The first approach modeled the household choice of leisure and energy services as distinct from its decision to consume purchased goods. This is depicted in a nesting structure that allows substituting leisure and energy aggregates by purchased goods in the top level and substituting leisure by energy in the second. The second approach considered all consumption goods (home produced, i.e. firewood energy or market-based) as separate from the consumption of the leisure commodity in the top of the nesting structure, while in the second level energy can be substituted by other purchased goods. The first approach implies that households maximize their CES utility function by substituting marketed versus home-produced goods (including leisure). Hence, leisure is substituted with firewood collection in the second nest of the utility function. According to the second approach, households decide first on the substitution between leisure and other aggregated goods, while the

latter is to be broken into work outside the house or inside the house, i.e. collecting firewood (Dufournaud et al., 1994, pp. 71–72). The model is calibrated to a SAM based on the 1983 national account data, among other sources, and various substitution elasticity values with respect to household utility according to the previously described approaches. The simulated experiment assumes that the efficient stoves are widely distributed, which is an optimistic scenario, and the gain in efficiency is 30%.

Results show that under both approaches the introduction of efficient stoves increases energy demand, so long as high substitution elasticity values are applied for the two utility levels. This is explained by the fact that greater elasticity values allow for higher substitution between commodities, which leads to increasing household consumption of a commodity with a decreasing price (i.e. energy service including firewood if efficient stoves are introduced). The two utility approaches are meant to represent two different types of households, in which the first approach represents a poorer household than the second approach. Therefore, by capturing the general equilibrium effects and considering other variables such as wages and profit, the first approach applies to wage earners while the second applies to entrepreneurs. Based on this classification and the use of different elasticity combinations, the study concludes that the higher the substitution elasticity values, the greater the demand for firewood of poorer households and the lesser for richer households. Therefore, the study recommends that policies to reduce firewood collection by households must consider the distinction between wage earners and entrepreneurs. The authors further state that if wage earners are poorer households, any energy-efficient policy that reduces wages is assumed to prolong a household's reliance on wood as a source of energy, which would lead to accelerating the environmental degradation in the Sudan (Dufournaud et al., 1994, p. 88).

4.2 Exchange rate policy

Several studies cover the exchange rate policy in the Sudan as an important trade policy instrument, one of which is Elbushra et al. (2010). In this study, the authors apply the standard CGE model of the International Food Policy Research Institute (IFPRI) and a SAM for the year 2000. They base the study's objectives on the World Bank and the International Monetary Fund's (IMF) recommendation to policy makers in the Sudan to devaluate the overvalued Sudanese Dinar[17], increase international competitiveness and improve the balance of payments. Therefore, they simulated devaluations of the currency by 5% and 10%. In addition, they simulated the currency to appreciate, referring to its 2005/2006 appreciation of more than 20% in the Sudan. Their conclusions were that a depreciated currency is better for the country than an appreciated one, with the former increasing the GDP, led by increasing agricultural exports

[17] The Sudanese dinar (SDD) was the currency of Sudan between June 8, 1992 and January 10, 2007. It is now replaced by the Sudanese pound (SDG).

despite a decreasing total domestic absorption. For the contrary case, appreciation decreases GDP despite increasing private consumption. They considered the depreciation of the domestic currency to have positive implications for the economy at large and recommended it as corrective policy in uniformity with the IMF and the World Bank recommendations.

Within the exchange rate policy context, Siddig (2012) applied the same IFPRI model and a more recent 2004 SAM for the Sudan to further assess the implications of currency devaluation. His study investigated the rationale behind the IMF's endeavor with the Sudanese government dating back to 1997 to implement a managed floating exchange rate with the assumption that exchange rate flexibility is essential to meet the international reserve target in Sudan. The authorities in the Central Bank of Sudan (CBoS) and the Ministry of Finance and National Economy in Sudan were, however, worried that flexible exchange increases inflation. Having reviewed the literature on the issue, which shows no agreement on the outcome of such policies applied to Sudan, Siddig (2012) applied the CGE model to simulate various levels of currency depreciation.

His conclusions did not appease the worries of the authorities in Sudan, as they revealed increasing prices for the majority of the commodities leading, on one hand, to stimulate the export oriented sectors of the economy, which benefited from higher returns in terms of the local depreciated currency. On the other hand, this comes with a slight increase in private income that doesn't suffice to maintain the *ex ante* private demand; hence, household purchasing power declines. Furthermore, domestic output of certain sectors would also deteriorate due to the increasing cost of intermediate inputs, especially imported goods. His final recommendation is that currency in the Sudan should not be allowed to depreciate in the short run, while in the long run policies that encourage both public and private investments should be adopted to create additional jobs that increase income and reduce possible negative effects of inflation, should devaluation occur.

4.3 International trade and economic sanctions

Economic sanctions, although closer to the field politics and potentially better addressed from a political economy prospective, were portrayed in Siddig (2011) as an extreme trade policy. In this study, an extension of the USA sanctions on the Sudan that started in 1994 and further tightened and joined by UN sanctions after the break out of conflicts in the Darfur region to include the EU was simulated and its impact was investigated. The study was mainly motivated by the American call for multilateral pressure on the Sudanese government in connection to the devastating conflicts in the Darfur region of western Sudan, especially during the period between 2003 and 2010, and other related political disagreements. More specifically, Siddig (2011) evaluated the impact of a scenario in which the European Union (EU) imposed economic sanctions on the Sudanese economy. The study applies the global CGE model of GTAP (Global

Trade Analysis Project) and its Africa Database to simulate banning the importation of all goods and services from the Sudan into the EU and all exportation from the EU to the Sudan.

The results suggested that both the income and expenditure sides of Sudanese GDP decline due to sanctions. The trade balance was found to experience a surplus due to the large decline in the country's imports, as imports fall for all product categories. However, the major impact came from decreases in EU-sourced imports such as light and heavy manufacturing, which represent big shares in the total Sudanese import value. While the Sudan appears to be a clear loser, the results show that the East Asian countries, led by China, will gain in this situation, because most Sudanese trade with the EU shifts to these countries. However, the 'Rest of Africa' region will have no welfare losses, and even experiences gains in some sectors. Domestic output in MENA, Egypt, Kenya, and Ethiopia will fall in some sectors due to the EU sanctions on Sudan. This can be seen as the regional implications of sanctions, which is mainly driven by the impact of trade on production, such as the increased production of oil seeds in the Sudan.

4.4 Agricultural efficiency gains and trade liberalization

Acknowledging the importance of the Sudanese agricultural sectors and, particularly, the rainfed traditional sector, Siddig and Babiker (2012) studied the agricultural efficiency improvement in a CGE modeling framework using a SAM for the year 2004 (Siddig, 2009) for the Sudan. Their work highlights the low productivity of the sector in general and its underrepresentation in agricultural GDP despite its high share in the country's cultivated land (60%) and agricultural employment (65%) (Siddig and Babiker, 2012, p. 52). Due to low yields and productivity in the sector, with erratic rainfalls and recurring civil conflicts, traditional agriculture was only able to contribute an average of 16% to total agricultural GDP in a decade. The study of Siddig and Babiker (2012) examined the extent to which improving the efficiency of traditional agriculture affects the people and economy of Sudan. They combined their efficiency-improvement experiment with simulating a more liberalized trade regime in the country in order to investigate possible gains that trade liberalization can bring.

Their results indicate that efficiency improvements, which may be achieved through enhancing farming education through effective extension services and improved productive capacity of subsistence farmers, increases agricultural output, factor income and GDP. The change in factor income increases income to households and, thereby, enhances private and public consumption demand and agricultural exports. The enhancement of farming education can be achieved through channeling public investment in rural infrastructure, which will in turn crowd in private and foreign investments. Combining efficiency improvements and trade liberalization indicated that output and exports of agricultural commodities benefit from more efficient farmers' use of resources and the cheaper intermediate and machinery imports, with the latter being brought about by the liberalization of trade. The authors recommended efforts to enhance technical efficiency in traditional agriculture of the Sudan (Siddig and Babiker, 2012, p. 67).

4.5 Climate variability and food security

Addressing the linkages between rainfall variability and food supply, Sassi and Cardaci (2013) combined a stochastic Monte Carlo analysis and a CGE model. They assess the effects of changes in rainfall on food security in the Sudan, represented mainly by the supply of cereal goods (i.e. millet, sorghum and wheat) and the corresponding changes to income to households, with the latter being a proxy for access to food as a measure of food security. The Monte Carlo analysis was applied to provide the likely changes in yield of the selected cereal crops based on historical data of rainfall patterns. The outcome of the Monte Carlo analysis was then used to augment the efficiency parameter of value added function in the IFPRI CGE model (Lofgren et al., 2002). The augmentation was introduced by multiplying the efficiency parameter of the value added function by a parameter reflecting the yield change of each crop due to changes in rainfall. Three CGE scenarios were simulated, namely the best, average and worst scenarios with yield shocks for wheat ranging from -32% for the best scenario to -45% for the worst scenario and those of sorghum and millet ranging from -27% to -53% for the best and worse scenarios, respectively.

Results indicated that the estimated rainfall changes have negative impacts on the two dimensions of food security. Namely, rainfall changes lead to a reduction in cereal supply that depicts the availability component and a marked inflation of cereal prices combined with income contraction to depict the access to food component of food security. The negative effects were found to be greater on the poorest households, while the overall economic performance, as depicted by GDP, was also found to deteriorate. Based on their findings, which show quite strong interconnection among climate change and variability, poverty and food insecurity in the country, the authors recommended the implementation of an integrated policy-making approach that accounts for these components together.

4.6 The division of the Sudan

In July 2011, the biggest African country by area, the Sudan, was divided into two countries: the Sudan (SDN) and the Republic of South Sudan (RSS). The division of the country was an outcome of more than 20 years of devastating civil conflicts between the central government and the Sudanese People's Liberation Movement (SPLM) in the south, which was ended by the signature of the Comprehensive Peace Agreement (CPA) in 2005. The CPA governed many political and economic issues through an interim period of six years (2005-2011) and granted the people in the southern part of the country a referendum on independence that was planned and performed in July 2011. One major issue during the interim period was the distribution of oil revenue, which was mainly (about 70%) extracted from fields located in the southern part of the country. Prior to the division, the central government was heavily dependent on oil revenue, which constituted major shares in its budget, country GDP and export value (Siddig, 2014, p. 738). According to the CPA, 50% of the revenue of oil exploited from wells existing in the south

goes to the central government, while the other 50% accrues to the interim autonomous government in the south. Therefore, the division of the country would enormously affect the economy of the Sudan.

Against this background, Siddig (2014) applied the global modeling framework of the Global Trade Analysis Project (GTAP) and its Africa Database to simulate the possible implications of the division on the economy of the Sudan. In a related scenario, his study also looked at the revenue from non-oil agricultural exports as an alternative following the reduction of oil revenue. Additional agricultural export revenue is assumed to be achieved through additional investments in the agricultural export sectors and is implemented in the model as increasing agricultural productivity. Similarly, the output of oil and the population of the Sudan were simulated to decline by 20% and 10%, respectively, to reflect the post-separation settings.

Based on the findings, the study recommended that policy makers in the Sudan focus on non-oil revenues, mainly from agricultural exports, to reduce the Sudan's heavy dependency on oil. It also stressed the implementation of measures that improve the efficiency in both the production and expenditure sides of the economy to absorb the separation shock on the government budget and current account balance. It further proposed additional measures, such as protecting pro-poor spending and rural development, to promote the peace and political stability essential for sustainable economic growth (Siddig, 2014, p. 747).

5 CGE applications to Nigeria

Nigeria is a special African country in several regards, in that it hosts the largest population in the continent, its per capita GDP is higher than that of the sub-Saharan Africa region and it is the largest crude oil producer and exporter in the continent (Siddig et al., 2014). In sharp contrast to these facts, 68% of the Nigerians live on less than US$ 1.25 a day and the country imports more than 80% of its domestically consumed petroleum products from abroad. The issue of petroleum products is linked to insufficient and/or inefficient domestic refineries, as well as multifold corruption allegations. It is therefore not surprising that four out of six CGE-based studies published on Nigeria address energy aspects, including energy prices, supply and subsidies.

The first CGE study on Nigeria reflected in the literature review was published in 1996 and it focused on policies related to energy prices (Iwayemi and Adenikinju, 1996). This study is covered in the first section of this chapter, together with another study on the impact on the Nigerian and Niger economies of exchange rate and energy price policies. The latter study also covered issues related to border trade between the two countries (Dorosh and Dissou, 1998). The study reviewed in the second section of this chapter questioned the persistent shortage of energy supply in the oil rich country of Nigeria and proposed alternative energy policies (Adenikinju and Falobi, 2006). In the third section, two studies proposing alternative policies related to Nigerian public investments with a focus on the prioritization of education and health services are reviewed (Odior, 2011a, 2011b). Finally, fuel import subsidies, their controversy and alternative policies related to them are covered in the fourth section of the chapter (Siddig et al., 2014).

It is to be noted that CGE applications to Nigeria are concentrated on the energy problem, which can easily attract researchers due to the significance of the petroleum sector in the economy and the surprising inefficiency of Nigeria's domestic manufacturing. The reviewed CGE studies on Nigeria are all of a policy-oriented nature with essentially no methodological focus. The study on the controversy surrounding the fuel imports subsidy, however, is the first ever published study using the MyGTAP model, which was developed by Walmsley and Minor (2013). The six CGE studies on Nigeria are discussed further in the following four sections of this chapter.

5.1 Energy prices and exchange rate policies

The energy crises and energy price problems in Nigeria, as well as their assessment within the CGE literature, have a long history. In 1996, the Pacific and Asian Journal of Energy published an article that addressed the energy problems in the net energy-exporting country of Nigeria (Iwayemi and Adenikinju, 1996). Iwayemi and Adenikinju (1996) based their assessment on the argument that the Nigerian energy crises were caused by distortions from energy pricing policies. Therefore, they utilized a CGE model to investigate quantitatively the economic and sectoral implications that higher energy prices might have on the Nigerian economy. Their study

concluded, unexpectedly and contrary to the constantly held views, that higher energy prices cause minimal distributional impacts in Nigeria (Iwayemi and Adenikinju, 1996).[18]

The borders between Nigeria and Niger (northern neighbor of Nigeria) are known to have been porous during the 1990s in terms of the movement of commodities. Therefore, substantial values of livestock, food products, textiles and small manufactures were traded in a parallel market (Dorosh and Dissou, 1998). The flow of these commodities between the two countries was affected by the different policies and shocks in each of the two economies. For instance, the 1994 devaluation of the CFA franc, the common convertible currency of Niger and the CFA franc zone, as well as changes in Nigeria's exchange rate and trade policies influenced each other and affected border trade. Therefore, Dorosh and Dissou (1998) examined historical movements in the real exchange rates of Nigeria and Niger and, based on their findings, linked CGE models of the two economies to simulate the impacts of policy reforms on economic output and income distribution. The CGE simulations included (1) an oil price shock; (2) alternative exchange rate policies in Nigeria; and (3) real depreciation of the CFA franc. Their focus was on illustrating the impact of these scenarios on the cross-border trade, real exchange rates on parallel markets, and real incomes of households, especially in Niger (Dorosh and Dissou, 1998).[19]

5.2 Consequences of energy supply shocks

The energy sector attracts most CGE applications to Nigeria. Another study that utilized a CGE model to address the sector is that of Adenikinju and Falobi (2006). Their study questioned the persistent oil supply shortages in Nigeria despite its vast oil endowments. According to them, Nigeria's oil shortages were manifested in regular queues at fuel stations that were often empty and in the spreading parallel markets all over the country. The authors claimed that even though these shortages were frequently occurring and causing huge economic and non-economic costs to the economy, no study had quantitatively estimated their implications for the economy (Adenikinju and Falobi, 2006, p. 2).

To assess the causes and consequences of the fuel shortages in Nigeria, the study relied on a survey and a CGE model. The survey was meant to provide the needed evidence concerning the perceptions and understanding of different economic agents of the causes and consequences of fuel scarcity and its impact on their economic activities. In addition, it was also expected to provide insights into the operation of the market. A total of 501 questionnaires were

[18] No access to the full article of this study was possible within the time of this paper preparation, which made it impossible to further elaborate on the model, data and assumptions behind the simulations and results.

[19] The full article of this study was written in French and the reference made here was based on the English abstract. It wasn't possible to further elaborate on the structure of their model and the data and assumptions behind their simulations as well as their results.

administered in the city of Ibadan, the largest city in Nigeria, which, together with Lagos, accounts for over 60% of total Nigerian gasoline consumption. The authors were therefore convinced that the evidence provided by their respondents in Ibadan represent many other parts of the country (Adenikinju and Falobi, 2006, p. 25). Besides the evidence and insights provided by the survey, a CGE model was applied to capture the impacts of supply shocks on the overall economy. It followed the structure developed by Dervis et al. (1989) and incorporated key features of the Nigerian economy. These features include unemployment, structural rigidities in labor and product markets, the important role of government investment in the economy and representing oil refineries by a separate sector. The model was calibrated to a 1999 SAM for Nigeria with 14 sectors, 2 of which are energy sectors.

After investigating the microeconomics of the oil supply shortages based on the survey data, two scenarios corresponding to the main sources of supply disruptions were simulated using the CGE model as follows: (1) a 10% reduction in capacity utilization of the refineries. This is consistent with the fact that refineries are operating at below full capacity, which has been the main reason for the petroleum shortages experienced in the country, and (2) the 10% reduction of the first scenario plus a 20% increase in the import price of petroleum products. The latter component recognizes the fact that increasing demand for imports increases import prices.

The results indicate that restrictions on the energy supply cause varied and intensive negative implications on the economy. The supply shock was found to lead to huge increases in the price of petroleum products. The authors argue in this regard that high prices were triggered by the attendant distortions of the economy and that the government must allow the market to play a greater allocative role in the sector and, therefore, reduce its interventions. From a distributional point of view, results indicate that consumers and poor households bear the main burden of the supply shocks. Nonetheless, the survey results also confirm that there are few players in the market chain who benefit from these supply disruptions.

In their outlook, the authors emphasized that their modelling results can be referred to as indicative of the qualitative directions of changes and that the quantitative values are only approximate indications. These limitations were due to the low quality of available data. Therefore, the findings of similar exercises could be more reliable should better quality data become available. In addition, the authors believed that such experiments extensively involve components of investment and economic growth; they therefore suggested that it would be better undertaken under dynamic settings rather than the applied comparative static one (Adenikinju and Falobi, 2006, p. 41).

5.3 Public expenditure and economic growth

Odior (2011a, 2011b) based their motivation to study the linkages among education, health and economic growth in Nigeria on the economic value of investments directed towards education

and health, as they lead to the accumulation of human capital, the security of manpower, higher productivity and, ultimately, economic growth (Odior, 2011b, p. 74). The latter study provided an extensive review of the literature on the linkages between economic growth and government spending on education, with a special focus on developing and least developed countries. The literature review shows that studies conducted during the last 40 years confirm the essential role played by education, evidenced by the contribution of education to labor productivity growth ranging between 13% and 30%. In total, most of the studies (theoretical and empirical) addressing the impact of education on economic growth, using various methods of analysis, have repeatedly agreed on the significant association between these two economic variables (Odior, 2011b, p. 76).

After estimating an econometric model that explores the relationship between health and education, a dynamic CGE model was used to assess the impact of alternative policies related to government investments in education on the overall economy. The model adopted CES functions at the top level of the production nest and CES and CET for the substitution between domestically produced goods from one side and imports and exports, respectively, from the other. A baseline scenario was generated for the period between 2004 and 2015 to provide a benchmark against which the policy scenarios of the two studies were compared. The baseline assumptions with respect to education were based on the empirically determined annual growth rates of the education sector. The baseline outcomes were validated using the historical path, while all exogenous variables were assumed to have a constant growth rate over the simulation period (Odior, 2011b, p. 83). The model was calibrated to a 2004 SAM for Nigeria with 13 sectors, of which four are related to agriculture, one to minerals, one to manufacturing and seven to services. Households are classified into three categories, including rural, lower urban and higher urban households[20].

The policy experiments simulated in the two studies (non-baseline simulations) increase the base year government spending on health in Odior (2011a) and on education in Odior (2011b). The applied increase is 10% of 2004 government demands (or 1.36% of GDP), introduced in the year 2005. The same value is cut from the other non-productive services sector (other services), which does not include health and education. This assures that total government demand is maintained.

Results of the two studies confirm that reallocating government expenditures away from unproductive service sectors to health and education enhances long-run economic growth. Results for the reallocation towards education show the annual growth rate of GDP to increase from 6.09% in 2004, to 7.58% in 2015. The author stressed the need for better-prioritized government spending, in which education and health receive considerable shares since they

[20] Refer to Odior (2011a, 2011b) for details on the baseline assumptions and data.

enhance macroeconomic and sectoral performance, contribute to reducing poverty, and contribute to human productivity growth. The author specially focused on the provision of basic education according to the concept of a citizen's right to basic education and suggests several channels that could together provide the needed investments, including government, private sector, communities, non-government organizations, bilateral donors and multilateral organizations. The integration of these sources according to the study was recommended with assurance that investments should be focused on improving the efficiency of existing government educational systems (Odior, 2011b, p. 85).

5.4 The controversy of fuel import's subsidies

Nigeria, the most populous country in Africa, has a higher per capita GDP than the sub-Saharan Africa region, but 68% of its population lives on less than US$ 1.25 a day, compared to 48% in sub-Saharan Africa in total. Nigeria is the second largest owner of oil reserves and the largest crude oil producer and exporter in Africa (Siddig et al., 2014, p. 165). Petroleum is also essential for the Nigerian economy, as it represents around 90%, 33% and 75% of its exports earnings, GDP and government revenues, respectively. Despite this, 80% of domestic demand of petroleum products is met from imported petroleum products due to insufficient and/or inefficient domestic refineries. The government has subsidized its imports for decades with the objective of assuring low prices of petroleum products for domestic users. However, major benefits of these subsidies accrue to importers and wholesalers (Siddig et al., 2014, p. 166). While the subsidy continued to increase with rising import value and its share in government spending grew, efforts of removing or reducing it were not successful because lower fuel prices are considered a strong benefit of the subsidy to the people of the oil-rich country of Nigeria.

Based on this background, Siddig et al. (2014) applied an economy-wide framework (MyGTAP model) to assess the effects of two different fuel subsidy reduction policies, combined with complementary policies aiming at absorbing possible negative consequences on Nigerian households and the Nigerian economy. The MyGTAP model is an extension of the standard GTAP model (Hertel, 1998). The essential extensions that are considered in the MyGTAP model include (1) the elimination of the regional household and its replacement with a detailed household account based on external data (e.g. country SAM or household survey) and a government account; (2) the inclusion of a detailed production factors account; and (3) the inclusion of transfers to households and the government in forms of remittances and foreign aid, which are both especially important for developing countries (Walmsley and Minor, 2013).

The GTAP database, which is the major underlying data for the model, is augmented using a 2006 SAM for Nigeria to include (1) 12 types of households, together with their detailed income, consumption, and savings patterns; (2) detailed linkages between household earnings and factors; and (3) linkages between the SAM and the 2012 Nigerian poverty profile to consider a poverty dimension in the analysis. The MyGTAP model includes a data module that allows for the

integration of data from the different sources, while assuring the overall consistency with the original GTAP database (Minor and Walmsley, 2013).

Four specific scenarios were simulated to address the fuel subsidy in Nigeria: (1) complete removal of the subsidy on imported petroleum products; (2) partial removal of subsidies so that petroleum product prices do not increase more than 10% of the baseline price[21]; (3) partial removal similar to the second scenario together with paying an equivalent value (the value saved from reducing the subsidy) to domestic fuel production; and (4) partial removal similar to the second scenario together with paying equivalent value (the value saved from reducing the subsidy) to poor households as a transfer. The third and the fourth scenarios are considered as shock absorbers against the subsidy reductions.

Results indicate that the first two scenarios, which removed the subsidy without any other policy interventions accompanying it, would decrease private household income but substantially increase government income and, thus, spending. These increases in government income do not show up in the welfare calculations, as they are not part of the households' income. The higher prices for petroleum products would negatively affect many sectors in the economy, especially those heavily dependent on petroleum products such as transportation and electricity, which will see their prices rise.

Accompanying the partial subsidy removal with a subsidy for domestically produced petroleum products (third scenario) generally leads to a lesser reduction in household income relative to the first two scenarios. It was also noted that the channels by which rural (poorer) and urban (less poor) households are affected differed: while urban households are mostly affected through their direct purchases of petroleum products, rural households are indirectly affected through their consumption of products and services that use petroleum products.

Results of the fourth scenario suggest that accompanying a subsidy reduction with transfers to rural households would not only promote pro-poor growth, but would also alleviate some of the negative impacts on real income of all households. It leads real income of rural households to increase by 2% to 8%, increases GDP, improves the government budget by reducing subsidy outlays and modestly improves the country's balance of trade. In addition, as prices of petroleum products increase (partial removal of the subsidy), this scenario was also found to promote import substitution by domestically produced petroleum products (Siddig et al., 2014, p. 174). The authors confirmed that their results are in line with both economic theory and the finding of other authors: the subsidies placed on fuel harm the economy as a whole and their replacement

[21] Refer to Siddig et al. (2014) for additional insights on the relationship between increasing the fuel price above a certain limit.

by targeted transfer policies improve household welfare[22]. The authors also pointed out that any benefits from the transfer policy might be challenged by inefficiencies and/or corruption during its implementation.

In their outlook, the authors suggested that should information on the quantities of petroleum products that the Nigerian government pays for but which never reach the consumer within the current scheme become available, the analysis would yield even larger positive effects of a subsidy reduction on the Nigerian economy than simulated in this paper should they be taken into account while undertaking such an exercise. Another possible direction of future extension suggested by the authors is the consideration of subsidies for efficient use as an alternative policy, such as promotion of fuel-efficient cars, trucks and generators. This would require information on the efficiency "gap" between current Nigerian infrastructure and the modern, energy efficient devices that would replace them (Siddig et al., 2014, p. 174).[23]

[22] A couple of case studies on the implications of subsidy removal in other countries are provided in Siddig et al. (2014).

[23] For more details refer to Siddig et al. (2014).

6 Conclusions

Many countries in the developing world lack the required capacities and data to provide evidence-based policymaking. As a consequence, they apply a trial-and-error approach to their exchange rate, trade and domestic tax policies, among others. Some countries base their policies on the experiences of other countries that are not necessarily similar in terms of economic structure, sectoral linkages and trade openness. This could be partially justified as well by the difficulty of basing economic policies on researched evidence due to the forward and backward linkages that prevail in any economy, which necessitates *ex post* and *ex ante* policy impact analysis on the entirety of economic actors. This reality was recognized during the 1960s by researchers and Johansen (1960) was the first to envisage a solution for it in the form of what is currently known as Computable General Equilibrium (CGE) models. A CGE model is a mathematical representation of the economic actors (production activities, commodities and institutions, including foreign countries) that depict the entire economic structure of a regional entity (country, state, village etc.) in a specific period, usually one year, and using a dataset with the entire body of economic transactions among them. The data set includes a Social Accounting Matrix (SAM) in addition to various parameter values. Johansen's CGE model was developed to assess the impact of economic policies in Norway and since then this method has developed rapidly and contributing significantly to the policy making process not only in the developed world, but also in developing countries.

The importance of CGE models rests on their ability to provide economy-wide impact assessments with huge flexibility in capturing a detailed representation of the economy depending on the availability of data. Despite its reliance on the detailed dataset, CGE models are applied to many countries, including those with relatively poor records of economic data. Due to their complex mathematical representation and their detailed data requirement, CGE models have made significant use of recent advancements in processor speed and storage capacity, and are now not only static but also dynamic and part of integrated systems in which they source inputs from and deliver output to various types of models such as crop, biophysical and climate models. The possibility of linking them to other models means their use is not only confined to economics, but can also be applied to various economic aspects of physics, environmental sciences, engineering and medicine, among other disciplines.

Despite the widespread use of CGE models, no comprehensive review of their applications to the different geographical regions of the world, the different types of problems they contributed to and the different disciplines they addressed is available. This kind of review is expected to show their usefulness and identify the regions, themes and disciplines that lack their applications and, hence, to direct future research. These are the main objectives of this current study. This study starts by exploring the history of CGE models, including the intensity of their applications worldwide and the areas of research in which they have been applied through the time, with a special focus on the period between 1980 and 2014. The study also explores classifying CGE

applications by the kind of services they have provided to advise policymaking, especially in developing countries.

Afterwards, the study focusses on four countries to provide deep assessments of CGE applications and identify areas for future research using CGE models. The selected countries are Palestine, Israel, the Sudan and Nigeria. The selection of these countries is related to research projects in which the author is involved, as well as personal interest. The study reviews all the CGE applications to the selected countries, and their areas of applications and the type of problems they addressed have been identified.

Major conclusions are that CGE applications to any of these countries are mostly concentrated on specific areas of research and specific types of problems. CGE applications to Palestine, for instance, are mainly focused on assessing the impact of Intifada and exploring policy options for Palestine away from the settings provided by the Paris protocol. CGE applications to Nigeria mainly address issues related to oil prices and government spending. This concentration is not a negative aspect in general, because research is usually motivated by the prevailing policy problems in the particular country. However, in some countries it seems that CGE applications are determined by the area of research given in the first study applied to the country. Researchers may recognize the usefulness of CGE models in addressing certain type of problems in their country and continue pursuing similar research without exploring other areas in which CGE models could be useful, such as addressing labor movement in Palestine or the environmental problems caused by the continuous sabotaging of oil pipelines in Nigeria.

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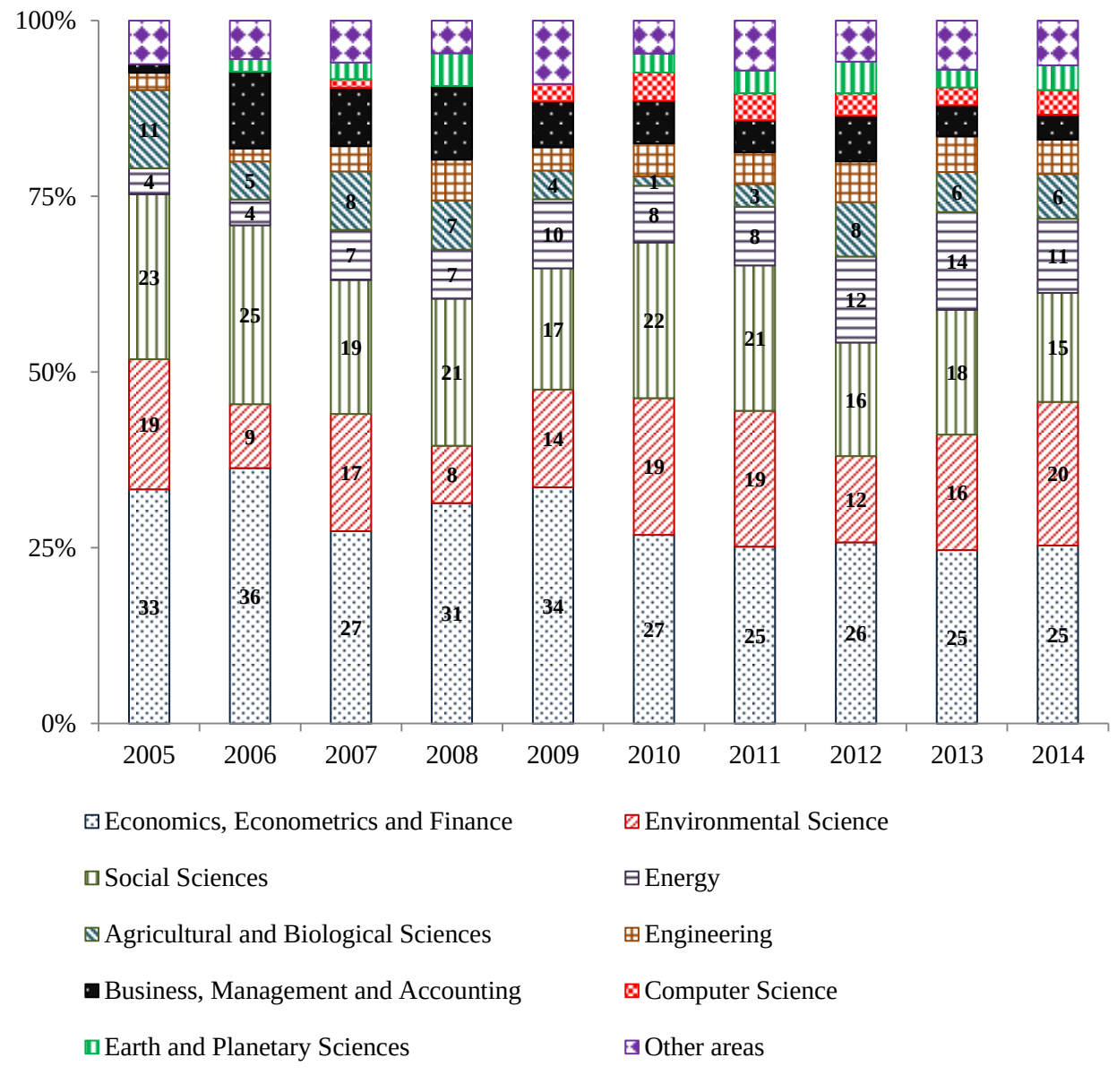
8 Appendix: Annually published CGE studies during the period (2005 - 2014) across disciplines



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