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Abstract

Computational general equilibrium models (CGE) and micro-simulation models (MSM) each have their own sets of strengths and weaknesses. Both have been widely used for the analysis of fiscal policies in developing countries, and many attempts have been made to link the two models, thereby combining their relative strengths. We survey a broad literature that uses a variety of approaches to apply linked CGE and MSM models to analyze fiscal policies, in particular taxes and tariffs, in developing countries. We conclude that the "top down" approach, in which the aggregate outputs of the CGE model feed into the MSM, is the most commonly used. Nonetheless, a "bottom up" approach, in which the MSM generates estimated parameters, such as effective tax rates, which are then used as inputs to the CGE, may also be quite useful. As an example, we also develop both CGE and MSM models of Pakistan in order to indicate the relative uses of each model, although we have not at this time linked the two models.

Keywords: Computable General Equilibrium, Micro-simulation, Fiscal Policy, Pakistan

JEL classification: H2, D58, D61, D63

I.   Introduction

The evaluation of tax policy reforms has typically addressed two main issues, the

efficiency and equity of the underlying tax code. Among the various analytical methodologies

used for the analysis, two stand out. These are Computational general equilibrium (CGE)

models and Microsimulation models (MSM). Each of them has certain advantages and

disadvantages that have been considered by different researchers. While each instrument

provides a useful type of analysis for each goal, they also include some drawbacks related with

their main structures. In order to exploit their strengths, there has been an interest in linking

these models either by integrating them or by treating them in a layered manner. The focus of

this paper is to address the efforts to link the two models and the methodologies that have been

used for that purpose.

A review of the literature provides an interesting insight into this effort at two levels,

empirically and methodologically. The empirical approach refers to the kind of reforms that have

been considered in a variety of countries, as well as what kind of economies have been applying

them. The methodological approaches are essentially mechanical: they identify what are the

main strategies used to link the two models, and what are the main strengths and limitations

associated with those strategies. This paper will survey the literature on these two approaches,

and will try to come to some general conclusions about whether there are any general

conclusions to be drawn. In addition, the paper provides as an example of the application of one

of these methodologies. We present a CGE model of the effects of tax evasion and entry into the

underground economy in Pakistan. We also provide an MSM analysis of tax incidence in

Pakistan. At this point, the two models have not been linked in a "top down" overall model,

which remains a topic of current research. However the two models should serve as examples of the two approaches and we provide a conceptual framework for integrating them.

In the next section, we provide a brief overview of CGE and microsimulation models as a means to discuss the integration of these important policy tools. In the section, we also provide a discussion of the benefits and the limitations of the separate models.

Computational General Equilibrium (CGE)

The use of computational general equilibrium (CGE) models to analyze tax policy began with the seminal papers of Shoven and Whalley (1972; 1973). These papers extended the Arrow-Debreu general equilibrium model to allow the introduction of taxes and tariffs. The approach, that originally incorporated only a few simple taxes in the context of static models, has been greatly extended. New versions of this approach use dynamic models with intertemporal optimization by all agents, and incorporate a wide variety of fiscal policies, not only taxes. It may be useful to mention some of the fiscal policies that have been frequently examined in the context of CGE models.

Among tax policies that can be incorporated into CGE models are sales taxes, value added taxes, tariffs on imports, export taxes, personal income taxes, corporate income taxes, wealth taxes, and land taxes. At the same time, subsidies such as price and consumption supports have been frequently analyzed. These models are quite flexible in dealing with different types of public current and capital spending. They have also proven to be useful, for example, in the analysis of the impact of the provision of public infrastructure on the productivity of the private sector, as well as a variety of other general fiscal policy issues.

More recent versions of the basic CGE model have attempted to incorporate financial assets, in particular money and bonds. Financial assets allow a considerable broadening of the

scope of fiscal policies to be considered. Most importantly, they allow the model to avoid the requirement of a balanced budget, since deficits can be financed by a mixture of borrowing and monetization, as well as foreign borrowing. It has also been possible to introduce endogenous central bank behavior, including open market operations, discount lending, and interest rate targeting.

Further extensions of the basic CGE model have been to incorporate a foreign sector into the previously closed economy models. Thus many researchers have estimated import and export equations, and incorporated them, along with the modeling of endogenous capital flows, exchange rate regimes, and import quotas to analyze a variety of issues in foreign trade. Similarly, the extension of the basic CGE model to include an intertemporal structure has permitted the numerical analysis of inflation and interest rates, as well as real growth rates, bringing the output of CGE models closer to familiar macro models.

Although CGE models have been extended to address a variety of economic policy issues, they have difficulties in certain areas. From the point of view of application to existing data, the use of representative agents is a problem. For example, a country may have survey data on thousands of households, but in order to incorporate this information into the CGE model, the households must be aggregated. That is, instead of thousands of households for which there is survey data, we would have, say, urban and rural representative agents, perhaps divided into income categories. Of course such aggregation discards a significant amount of useful information. Accordingly, many researchers have linked CGE models to micro-simulation models that do permit the incorporation of a high degree of detailed data, but do not have many of the endogenous modeling features of CGE models.

Strengths and limitations of the CGE

CGE models have become the standard tool for carrying out efficiency analyses of tax reforms in specific economies. These models have been popular in studying the economy wide impact of distortionary taxes. In the context of personal income taxation, their detailed treatment of work-leisure trade-off is important in analyzing labor force participation issues. In the case of indirect taxation, these models provide a linkage with the utility functions of the households and then indicate the welfare costs of taxes. (Ahmed and O'Donoghue 2007)

CGE models have been subjected to a extensive analyses of their strengths and weaknesses. Their main advantages are that they are strongly founded in microeconomic theory, take into account economic flows in a flexible manner, and incorporate explicitly price effects. In addition, the specifications can be changed according to analytical needs. In addition, they partially avoid the Lucas' critique, because there are no problems with expectations being incorporated in the estimated parameters used. (Petersen 1997)

Although CGE models have considerable theoretical depth, they take a very flexible approach to statistical methodology. Some of the operational drawbacks are that the results are very sensitive to specification forms, closure rules and the choice of base-year. Additionally,many of the parameters of the model are derived from a single year's Social Accounting Matrix (SAM). The expected structural changes in technology over time are ignored. In addition, the real world applicability of general equilibrium theory itself has been under scrutiny for a long time. (Petersen 1997)

CGE models often include only one representative consumer, making it difficult to study effects on equality between different households. Other models include more than one consumer,

but are likely to have only a small number of representative household groups. This implies that

the equality analysis will tend to be too basic. (Åvitsland and Aasness 2004)

Micro-simulation models (MSM)

Micro-simulation models (MSM), which explicitly incorporate individual level data on

households, individuals, or firms have a long history in policy analysis. The methodology

behind micro-simulation models is based on the work of Orcutt (1957) and Orcutt, Greenberger,

Korbal, and Rivlin (1961). Orcutt's original work in this area came out of a concern that the

distributional aspects of policy changes were not considered in models of that period (largely

macro growth models). The early MSMs envisioned a dynamic element in modeling where the

base data were micro files of households, individuals, or companies. Baroni and Richiardi

(2007) point out that these early dynamic micro simulation models did not live up to their

promise, in large part because of data constraints since public use micro data were hard to come

by in the 1950s and early 1960s. The model development then took a step backwards in a sense

in that models of the 1980s were static in nature. In the 1980s substantial gains were being made

on the data front through the expansion of publically available household surveys and the

popularity of the IRS Statistics of Income Program, which made non-identified micro-level tax

return data available to researchers in the U.S.

As the availability of micro data became less of an issue, focus turned again to the static

nature of the micro-simulation methodology in the early 1980s. In the tax policy world, policy

makers and researchers alike called for "dynamic scoring" of tax legislation that would

incorporate the macroeconomic impacts of tax changes (such as increased economic activity) in

the revenue estimates of tax legislation. Dynamic scoring called for adapting, some might say

modernizing, the heavily used static micro-simulation models in the U.S. This trend toward

more dynamic microsimulation modeling was not unique to the U.S. In Australia and Canada (among other countries) policy makers were calling for more dynamic models to analyze the impacts of tax and expenditure policy changes on income, employment, and long term tax revenues.

The uses of micro-simulation models have been extended to a number of different types of policy issues across many countries throughout the last three decades. The specific uses of micro-simulation models range from estimating the distributional impact of changes in the taxation of social security benefits (Wixon, Bridges Jr et al. 1987), to the demand for day care services in Denmark (Baekgaard 1996), to the implications of sales tax reform in Canada (Gupta, Kapur et al. 2000). Many models have been designed specifically for the analysis of taxes in developed and developing nations. By far, the greatest appeal of these models is the detail they provide in terms of distributional analysis.

There is no one unique approach to micro-simulation modeling. However, we can classify micro-simulation models into (at least) three general types: *static, micro-dynamic/macro-static,* and *dynamic. Static* models are used most often to simulate the short-term distributional and revenue impacts of detailed changes to tax and transfer programs. *Micro-dynamic/macro-static* models allow behavior to change, but with the overall constraint that GDP remains the same. *Dynamic* models are often used to simulate the impact of changes in policy (tax and transfer programs for example) on macro aggregates and, in some cases; the data are endogenously aged for population growth and other demographic changes.

A typical tax policy oriented micro-simulation model is comprised of three pieces: (1) a micro-level database (for example, information from tax returns for individuals or corporations for the base year and future years), (2) a tax calculator (a computer program that calculates the

tax paid under alternative tax structures and which may be supplemented with behavioral changes associated with the tax changes), and (3) an output program which categorizes taxes paid by income group, tax burdens, winners and losers, and the overall change in revenue.

Strengths and limitations of the MSM Approach

A number of researchers agree that the relevance of the MSM approach lies in providing in detail the behavior of individual firms and households. These agents are observed at a highly disaggregated micro level which can be expressed in two types of direct applications (Bourguignon and Spadaro 2006). First, it is simpler to identify the likely winners and losers of a reform under a disaggregate sample of economic agents rather than a few aggregate agents. Second, the results obtained with an MSM at the level of individual agents can be aggregated at the macro level, thereby providing a more accurate evaluation of the aggregate financial cost or benefits of a reform.

In the case of tax reforms, MSM is often the preferred methodology when equity analyses of tax reforms are undertaken. However, while MSM helps to estimate the distributive effects of a reform, it is limited due to the assumptions that individual behavior is largely unchanging, as well as its inability to model prices, wages and macro variables (Davies 2004). These assumptions may cause it to miss valuable information because of its partial equilibrium nature (Åvitsland and Aasness 2004).

Linking CGE and MSM

In the remainder of this paper, we set the stage to bring together the best of both modeling traditions—CGE and MSM. The ultimate concept is to provide a tool that analyzes the macro economic impact of a policy change (such as a new tax, changes in tax rates, etc.,)

integrated with a micro data set that enriches the analysis by fine-tuning the types of policies that can be analyzed and providing detail distributional analysis. This is not the first attempt at such modeling, but in our view, this is the first attempt to develop such a model for tax analysis in a developing country that deals with some of the stickiest issues of tax policy—tax compliance, self-employed versus institutionally employed, and the impact of alternative tax policies on growth and investment.

The next section will survey the existing literature that has attempted to link CGE and MSM models. We will categorize the literature in various ways, and also discuss the countries to which the analysis has been applied.

II. Survey of the literature

This section presents a review of the literature on linking CGE and micro-simulation models or micro datasets and highlights the pros and cons of resulting models. This review aims to emphasize the works that investigate the impacts of fiscal policies, with applications to developing countries. Some of the fiscal policies that have been examined through the use of CGE and micro-simulation models are: reductions in tariffs; changes in direct taxes; changes in consumption taxes; adoption of cash transfers, and implementation of food subsidies. In addition, the general focus has been to analyze the effect of fiscal policies on labor markets, income distribution, and poverty.

This survey covers almost 30 years, from 1984 to 2012. This literature review is organized according to the approach used to link the CGE and the micro dataset. Five different approaches have been identified: *top-down*; *top-down with representative household groups*; *income distribution function approach; top-down/bottom-up*, and *fully-integrated*. Table 1

summarizes the main advantages and disadvantages of each approach presented in this section. The analysis of the literature review shows how the efforts to integrate the CGE and MSM reflect the data requirements, the availability of modeling resources, and the certainty about how to model the economy (Davies 2004). Under those conditions, it is difficult to uniquely identify which method superior, but rather it is more useful to define which method suits best the objectives of the analysis

The ***top-down approach*** has been used to establish a connection between the CGE model and the micro-simulation model. Robilliard, Bourguignon et al. (2001) introduced the methodology. First, the micro dataset is used to estimate key macro variables that appear in the CGE model (wages, profits, employment etc). These variables are econometrically estimated using other relevant variables available in the micro dataset (age, education, region, etc). This first step provides an initial set of coefficients for the micro simulation model. Second, the values observed in the micro data are used to define consistent benchmark values for the key macro variables in the CGE model (for example, the sum of a variable x over the micro-units will be equal to a macro variable X that is included in the CGE model). Third, a policy change is simulated by the CGE model, modifying the macro variables of interest (from X to X*, for example). Fourth, the values estimated for the key macro variables (X*) are imposed on the micro-simulation model. In this way, a new set of parameters fully consistent with X* is estimated for the micro model. And finally, the effect of a policy change on each micro-unit can be evaluated using this new set of parameters estimated for the micro-simulation model.

The advantage of the *top-down approach* is the richness in terms of household behaviors that can be modeled. One disadvantage of this approach is that the coherence between the macro

and micro models is not guaranteed. Another weakness is that the feedback effects of household behaviors are not taken into account in the CGE model.

Robilliard, Bourguignon et al. (2001) presents an application of the *top-down approach* to study the effects on poverty and inequality of the financial crisis that hit Indonesia in 1997. In addition, they compare the impact of alternative social policies (food subsidies, household transfers and a public work program directed to unskilled workers) designed to protect the poor during the crisis. The initial set of coefficients for the micro-simulation model is estimated using OLS and multi-logit models. The CGE model communicates with the micro-simulation model through a vector of prices, wages, and aggregate employment variables. They estimate that the most efficient social package in terms of poverty reduction appears to be household transfers.

Bourguignon, Robilliard et al. (2003) also use the *top-down approach* to investigate the impact of a change in the foreign trade balance (before the Asian financial crisis) on income distribution and poverty in Indonesia. However, the main purpose of the paper is to illustrate the methodology and compare the *top-down approach* to the *top-down-RHG approach*, which assumes that the impact on each micro-unit is given by the simulated impact on representative households in the CGE model (see below for a detailed description). They show that the results estimated differ substantially, depending on the chosen approach. The *top-down approach* should produce higher quality results because under this approach important household behaviors can be modeled and taken into account on inequality analysis. However, this will be true only if the representation of these behaviors is satisfactory. As mentioned by Bourguignon, Robilliard et al. (2003), the problem is to judge whether these behaviors are properly modeled. In conclusion, more work is needed to take full advantage of the *top-down approach*.

Another application of the *top-down approach* is presented by Bussolo and Lay (2003) for the Colombian economy. The paper studies the effects of the trade liberalization of the 1990s on income distribution and poverty. The average wage in each labour market segment, the average profits for different activities, the shares of self-and wage-employed for each segment, and the relative price of food and non-food are the variables extracted from the CGE model after the policy simulation and transmitted to the micro-simulation model. The micro-simulation model computes changes in earnings and the shares of self-and wage-employed for each segment. The CGE-microsimulation model estimates that the trade liberalization shock reduced poverty in Colombia.

There are several other examples of the top-down applications including Ortega (2011) and Raihan (2010). Hérault (2006) identifies advantages of this method in that it avoids the use of representative agent assumptions and that it does not formally require full reconciliation of micro and macro data. The paper shows that trade liberalization appears to be pro-poor and to have a limited dampening effect on inequality. Dartanto makes a similar application for Indonesia (2010). He measures the impact of world price volatility and import tariffs of rice on poverty. The model identifies 3 main institutions (government, enterprises and households), 25 industry categories, and 9 factors of production.

The *top-down* approach has also been used for policy analysis in developed countries. Buddelmeyer, Hérault et al. (2009), for example, provides an application of this methodology for Australia.

The ***top-down approach with representative household groups (top-down-RHG)*** has been used to establish a connection between the CGE model and the information available in micro databases. Agénor, Chen et al. (2003) present a description of this procedure. First, a

traditional CGE model with representative households is used to simulate a policy change, producing changes in key macro variables (consumption, income, prices etc) for each household category. Second, the households available in the micro dataset are classified into the categories of households available in the CGE model. Finally, the changes estimated by the CGE model are imposed on each individual in the micro dataset.

Under the *top-down-RHG* approach, all individuals pertaining to the same household category will be subject to the same impact estimated by the CGE model. This is different from the previous approach, in which each individual is subject to a different impact after a simulated policy, depending on the specific individual characteristics. The advantage of this approach is the simplicity (compared to the previous approach, for example). As mentioned by Lofgren, Robinson et al. (2003), approaches to link the CGE and the micro dataset that are based on representative household groups require fewer resources in terms of data, time, and skill, compared to alternative approaches that are not based on representative household groups. One disadvantage of this approach is that it does not account for heterogeneity among agents within household categories. Another weakness is that the feedback effects of household behaviors are not taken into account in the CGE model.

Agénor, Chen et al. (2003) use a CGE model representative of a typical middle-income developing country and the *top-down-RHG* approach to study poverty reduction policies. More specifically, they simulate the effects of a cut in the minimum wage and an increase in the employment subsidy on unskilled labor on income distribution and poverty. Changes in income, consumption and employment extracted from the CGE model are imposed on each household in the survey data. The main purpose of the paper is to compare the *top-down-RHG* with the *income distribution function approach* (see below for a detailed description). Despite not finding

fundamentally different results under the two approaches, they show that there is a potential for very large differences in terms of poverty and income distribution results. Additional examples of such models are found in Coady and Harris (2001) De Barros and Corseuil (2002), and King and Handa (2003).

The ***income distribution function approach*** provides an alternative way to benefit from the information available in disaggregated datasets while running policy simulations in macro CGE models. The following methodological description is strongly based on the work of Agénor, Chen et al. (2003). First, it is necessary to classify the households available in the micro dataset into the categories of households that exist in the CGE model. Second, a parametrically estimated distribution of income is assumed for each household category. Third, the parameters of the distribution of income within each group are estimated using the micro data. Fourth, a traditional CGE model is used to simulate a policy change and obtain the new group-specific mean incomes. And finally, the new group-specific mean incomes estimated by the CGE model are used to estimate the new distribution of income between groups of households and the new overall distribution of income. This procedure assumes that the distribution of income within representative household groups is not altered by the policy change, that is, the shape of the distribution is assumed to be fixed and only the distribution mean is subject to changes.

The advantage of this procedure, according to Lofgren, Robinson et al. (2003), is its' sparseness because the only additional data required is the set of parameters estimated for each within-group distribution. One disadvantage of this approach is that the within-group distribution of income is assumed to be fixed across simulations. Lofgren, Robinson et al. (2003) explain that for this assumption to be a close approximation of reality, the representative households in the CGE model must be highly disaggregated. In addition, as showed by Boccanfuso, Decaluwé et

al. (2003), the assumption that one income distribution represents all groups of households and is invariant across policy simulations may result in misleading conclusions in terms of inequality and poverty analysis.

Decaluwé, Patry et al. (1999) provides an application of this procedure. They evaluate the impact of a fall in the price of exports and an import tariff reform on poverty and income distribution for an archetype African economy. The household micro data is used to estimate the parameters of the income distribution function of each group of households included in the CGE model. A Beta distribution was assumed. Decaluwé, Dumont et al. (1999) also uses the methodology and the assumption of a Beta distribution to evaluate the effects of a significant current account deficit and an increase in the unskilled labor supply on poverty and inequality in an archetypal semi-industrialized economy. Also assuming a Beta distribution, Agénor, Chen et al. (2003) study the distributional and poverty effects of a cut in the minimum wage and an increase in the employment subsidy on unskilled labor in a typical middle-income developing country. An alternative approach is given in Colatei and Round (2000), who assume that the income distribution function of each household group included in the CGE model follows a lognormal distribution. They study the effects on poverty of a range of revenue-neutral redistributive policies in Ghana.

The ***top-down/bottom-up approach*** was introduced by Savard (2003). First, the CGE model generates the outputs to feed the micro-simulation model (a vector of prices for goods and factors, for example). Second, the micro-simulation model and the outputs of interest extracted from the CGE model are used to estimate the behavior of each micro-unit (household behavior in terms of consumption and labor supply, for example). Third, the individual outputs estimated by the micro-simulation model are aggregated over all micro-units and will feed the CGE model

(for example, individual consumption is aggregated over all households, producing a single vector for consumption). Finally, the CGE model produces a new set of outputs that will feed the micro model. As a response, the micro model will produce a new set of individual responses that will feed the CGE again. The process between the CGE and the micro model continues until a solution is achieved.

One advantage of this approach, compared to the top-down approach, is that it takes into account the feedbacks of households generated by the micro model back into the CGE model. According to Savard (2003), another advantage of this procedure is that it is possible to use the exact income and expenditure data available in the micro dataset. There is no need of adjusting the micro data to the national accounts and there is no need of balancing income and expenditure, as required by the fully-integrated approach (see below for a detailed description of this approach). He also explains that this approach imposes fewer limits on microeconomic household behavior, compared to the fully-integrated approach.

Colombo (2010) describes two drawbacks of the TD/BU approach. First, the conclusions may change in a fundamental way depending on how feedbacks from the MSM model are imposed on the CGE model. And second, it is possible to run the model without previously solving inconsistencies between the micro and macro datasets, however, these data inconsistencies can affect results seriously. The researcher may be unable to distinguish whether the resulting changes are due to feedback effects or due to data inconsistencies.

Savard (2003) presents an application of the *top-down/bottom-up approach* for the Philippines. The paper investigates the effects of a reduction in import tariffs on poverty and income distribution. However, the main objective of this paper is to introduce the top-

down/bottom-up approach as a new methodology to link the CGE model and the micro dataset and to present its main advantages compared to the other approaches.

Some examples of the application of the top-down/ bottom-up (TD/BU) approach can be seen in the studies from Savard for the Philippines. One study (Savard 2010) uses the CGE-MSM model with endogenous labor supply and unemployment to explore the impact of scaling up infrastructure spending in the Philippines under three funding mechanisms (increases in the VAT, the income tax rate and foreign aid). The CGE model is categorized into 20 sectors and it is assumed that capital is not mobile between sectors. Labor is divided between formal and informal, and the choice of combinations between these two factors is determined by a CES function. The results show that infrastructure spending reduces poverty and that foreign aid is the most equitable funding mechanism, while a VAT provides the strongest poverty reduction.

Another study compares the results of using the Representative Agent (RA) and TB/BU approaches in terms of poverty variation and income distribution as opposed to macroeconomic and sectoral results (Savard 2005). He emphasizes that the RA approach is not able to generate intra-group variance as it represents the structure of wealthy households much more than that of poor ones. In that sense using aggregated RA models for poverty and inequality reduction could lead to biased policy conclusions.

An example of the use of CGE-MSM model for tax policy analysis is the study of Avitsland and Aasness for Norway (2004). They evaluate the effect on equity of three taxation reforms (a uniform VAT rate on all goods and services, the abolition of the investment tax and a non-uniform VAT on the lines of the reform of 2001). The CGE model has 41 private and 8 governmental production activities and 24 commodity groups. All factors are completely mobile and malleable, the distribution of full consumption and leisure is determined by a CES function,

and the government expenditure is exogenous. They link the CGE and the MSM models by multiplying consumer prices, nominal pre-tax incomes, wealth and transfers in the MSM model by percentage changes in corresponding variables in the CGE model. It is found that under the third taxation reform, the equality is increased. The *top-down/bottom-up approach* has also been used for policy analysis in other developed countries. Magnani, Piccoli et al. (2011), for example, provides an application of this methodology for France.

Finally, an example of the ***fully-integrated approach*** (also called bottom-up or integrated multi-households CGE analysis) is presented by Cogneau and Robilliard (2000). First, the micro dataset is used to estimate household behavioral equations econometrically (wages and value added by sector, for example). The residuals of these econometric equations are preserved to be included in the model as exogenous variables that will take into account unexplained heterogeneities between households/individuals. The parameters that cannot be estimated econometrically are from the literature or derived from the household survey or the SAM. Second, the equations estimated for each household are aggregated and compose the CGE model, that is, the CGE model is based on information from the micro dataset. The CGE model includes all households. We can say that the number of representative households in the CGE model under this approach is equal to the number of households in the micro dataset. In Cogneau and Robilliard (2000) there are thousands of households, factor, and activity accounts in the full model SAM. However, they explain that it is possible to derive an aggregate social accounting matrix (SAM) with a reduced number of accounts. And finally, a solution algorithm will seek the equilibrium prices that will clear excess demands. As explained by Cogneau and Robilliard (2000), at each step all the micro behavioral functions will be recomputed with new prices. This makes some microeconomic behaviors endogenous. According to Cogneau and Robilliard

(2000), since the microeconomic specifications constitute the foundations of the model, this procedure could be called bottom-up approach.

According to Cockburn (2002), an advantage of the *fully-integrated approach* is that all the heterogeneity of households is included into the CGE model, making possible to model the effects of policy changes on each individual household. Cororaton (2003) explains that the approach captures the interaction between policy reforms and individual responses. In this way, individuals' feedbacks to the general economy are also taken into account. One disadvantage is that the reconciliation of the microeconomic data with the macroeconomic data is a requirement and may be difficult. Another disadvantage is that the fully-integrated approach is more limited in terms of household behaviors that can be modeled than the TD and TD/BU layered approaches. According to Savard (2003) and Colombo (2010), certain types of equations that are commonly included in a behavioral model are not easily modeled within standard CGE modeling software. As a result, fully-integrated models are relatively limited in terms of capturing the behavioral responses of the agents to the policy reforms that are implemented.

Cogneau and Robilliard (2000) use the *fully-integrated approach*, as previously detailed, to study the impact of many different growth strategies (two different policies for a formal sector "push" and four different policies for the development of the agricultural sector) on poverty and inequality in Madagascar. In their model, which captures the heterogeneity at the household level, households differ by their demographic characteristics, labor market position, preferences of consumption, preferences of labor supply and their endowment of physical and human capital.

Cockburn (2002), Cororaton (2003), Decaluwé, Dumont et al. (1999), Boccanfuso, Decaluwé et al. (2003), Aka and Diallo (2011) all provide analyses using fully integrated models in developing countries. In addition, the fully-integrated approach has also

been used for policy analysis in developed countries. Slemrod (1984) provides an application of this methodology for United States, Tongeren (1995) and Tongeren (1997) for Netherlands and Plumb (2001) for UK.

Besides these approaches, there have been other attempts to integrate the macro-micro models. One alternative is proposed by Zavaleta (2010). His study analyzes the effects of an increase on natural resources output on poverty and inequality, and compares different redistributive policies. He uses an exact aggregated representative household model (EARH) which consists in using exact aggregation conditions to create a relatively small number of representative households in the CGE. The approach applies exact aggregation conditions of household behavior, which links the CGE and MSM models through a limited number of representative households. The approach accounts for substantial heterogeneity in household behavior and is consistent with econometrically estimated demand functions at the micro level.

Another approach is used by Annabi and other authors whom develop two papers for Senegal and Canada. The first one, developed with Cisse (2005), examines the poverty and income distribution effects of a complete trade liberalization policy in Senegal. The second one analyzes the impact of an increase in foreign competition on Canadian labor markets, income distribution and poverty (Annabi, Fougère et al. 2010). For both studies, they use a sequential dynamic MSM-CGE model which combines the growth aspects of a dynamic CGE model with the detailed information provided by MSM techniques.

Table 1 summarizes the main advantages and disadvantages of each approach presented in this section. The analysis of the literature review shows how the efforts to integrate the CGE and MSM lies in the data requirements, the availability of modeling resources, and the certainty about how to model the economy (Davies 2004). Under those conditions, it is difficult to

uniquely identify which method is better than the others superior, but rather it is more useful to define which method suits best the objectives of the analysis.

In the last sections of this chapter, we provide an overview of two distinct models—a CGE and a microsimulation for Pakistan. The use of Pakistan is largely a function of data availability, but the point in these sections is to remind readers of the important components of each model and to provide some intuition regarding how they might be integrated in one of the frameworks that has been summarized in this chapter.

III.   A CGE Analysis of Tax Potential: A "Top Down" Application to Pakistan[1]

a)   Background

This section develops a dynamic general equilibrium tax model, applied to Pakistani data, in which optimizing agents evade taxes by operating in the underground economy. The model will generate dynamic paths for various macro outcomes for the economy. These macro outcomes will then serve as inputs to a micro-simulation model for Pakistan, to be described in the next section. This micro-simulation model will, in turn, generate detailed outcomes at the sectoral and household level, resulting from the macro inputs from the CGE model. This exercise will thus serve as an example of the "Top Down" approach. This is one way to integrate the two types of models. Another methodology is to integrate the micro data and behavior into the CGE framework by using the micro data as the baseline data base. The benefit from such a bottom up approach is that, for tax policy, very detailed changes in tax law can be evaluated, simulated first within the micro-simulation model to calculate new effective tax rates. These rates can be used within the CGE model to determine changes to macro aggregates, which can then be fed back to the micro-simulation model. The result is a very detailed analysis of tax

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[1] This section is based upon Feltenstein, A. and M. Cyan (2012). A Computational General Equilibrium Approach to Sectoral Analysis for Tax Potential: An Application to Pakistan, International Center for Public Policy , Andrew Young School of Policy Studies, Georgia State University.

changes that includes the macro changes and the micro detail of tax policy and distributional

analysis. This type of top-down/bottom-up integration will be investigated in the future.

The intuition of the CGE model is that firms optimize their returns to capital by evading

taxes, but face certain constraints in doing so. The cost to firms of evading taxes is that they find

themselves subject to credit rationing from banks. Our simulations will show that in the absence

of budgetary flexibility to adjust expenditures, raising tax rates too high drives firms into the

underground economy, thereby reducing the tax base. Aggregate investment in the economy will

be lowered because of credit rationing. Taxes that are too low eliminate the underground

economy, but result in unsustainable budget and trade deficits. Thus, the optimal rate of taxation,

from a macroeconomic point of view, may lead to some underground activity.

We apply our model to Pakistan, and calibrate it to macro data for an 8 year period from

2004-2011. We then use a sectoral breakdown of tax data generated by the model to estimate tax

gaps on a sector by sector basis. We will see that certain sectors are currently paying taxes

below their potential, while others may be above their tax potential. These sectoral gap estimates

may be used as indicators of where greater tax enforcement efforts should be directed. On the

other hand, these sectoral indicators give little information about evasion at the level of

individual firms or households. In order to generate information on evasion at the micro level,

the outputs generated by the CGE model will be used as inputs for the micro-simulation model in

the next section.

The cost of operating in the underground economy is modeled in terms of the inability to

borrow from the official banking system. Banks in the model are assumed not to have perfect

information about the firm's true ownership of assets and its associated true tax obligation. We

assume that due to collateral requirements, credit is provided only in relation to the firm's

implied ownership of assets, which is determined from its actual tax payment. The idea here is that in the face of default, banks can only seize those assets that have been officially declared by the firm. Hence, the higher the extent of tax evasion, the lower the implied value of firm assets, and the lower the amount of credit provided by the banking system. Our approach has some similarity to Kiyotaki and Moore (1997) who model credit limits on loans. These limits are determined by estimates of collateral which, in turn, are determined by estimates of durable asset holdings by borrowers. Here, tax payments are used to estimate the value of the durable asset of the borrower, as the asset cannot be directly observed.

We assume that firms can operate partially in the formal and partially in the underground economy. That part of their operation that takes place in the legal economy pays taxes and can borrow from the banking system. That part that is underground does not pay taxes and cannot borrow. Admittedly this distinction is artificial, but captures some of the benefits and costs of operating in the underground economy discussed in the literature. In reality, the underground firm may still be able to finance its investment needs by relying on trade credits or borrowing from secondary lenders who charge higher than market interest rates and are willing to incur high risks.

Our approach also assumes that firms can evade taxes without any real risk of detection or punishment. Shleifer and Vishny (1993) point out that where public pressure on corruption or the enforcement ability of the government is relatively weak - as is the case in many developing countries - this is in fact a fitting assumption.

b) **Model intuition**

We have developed the formal structure of a dynamic general equilibrium model that endogenously generates an underground economy. Much of the structure of our model is designed to permit numerical implementation for Pakistan. Our model has n discrete time periods. All agents optimize in each period over a 2 period time horizon. That is, in period t they optimize given prices for periods t and t+1and expectations for prices for the future after t+1. When period t+2 arrives, agents re-optimize for period t+2 and t+3, based on new information about period t+2. The dynamic structure is described in detail in Blejer, Feldman, and Feltenstein (2002).

Our approach is related to Gordon and Li (2009). Here the government is able to tax a firm only if that firm uses the banking system. When the firm uses a bank, it is assumed that the bank has access to the firm's balance sheet, which it records. The bank then makes this balance sheet information available to the government, which is then able to collect taxes, in particular sales taxes, based upon its knowledge of the firm's balance sheet.

We use a dynamic approach in which both firms and banks optimize and in which the benefits to a firm of accessing the banking system are endogenous. Our approach is related to Dabla-Norris and Feltenstein (2005). Here a firm compares the return to capital with the marginal tax rate on capital income. If the return is greater than the tax rate, then the firm pays the full capital tax. If it is less than the tax rate, then the firm reduces its tax payments proportionally. Hence the firm enters the underground economy gradually, as the gap between tax rates and returns to capital increases. At the same time banks use a firm's capital tax payments, combined with the capital tax rate to obtain an estimate of the firm's minimum capital

value. This is thus the bank's estimate of the firm's collateral, and hence reflects a minimum estimate of the value of assets that the bank can seize if the loan fails. This approach is motivated by the collateral constraints in Kiyotaki and Moore (1997). We should note that we are thus focusing on only a single type of tax evasion, namely, evasion of the capital income tax. As we shall see, indirect tax rates can change rates of evasion of the corporate income tax by changing the rate of return to capital. We do not, however, consider direct evasion of sales or value added taxes, for example.

Our approach has the key feature that tax evasion is based upon optimizing behavior by firms, rather than upon some exogenous firm characteristics. In particular, enterprises, as well as individuals, will balance their need to invest by borrowing from the banking system with their desire to reduce their tax obligations. This optimizing behavior is, of course, forward looking.

c)   A General Equilibrium Specification

Our model has n discrete time periods. All agents optimize in each period over a 2 period time horizon. That is, in period t they optimize given prices for periods t and $t+1$ and expectations for prices for the future after $t+1$. When period $t+2$ arrives, agents re-optimize for period $t+2$ and $t+3$, based on new information about period $t+2$.

Production

There are 8 factors of production and 3 types of financial assets. The five types of capital correspond to five aggregate nonagricultural productive sectors. An input-output matrix, A_t, is used to determine intermediate and final production in period t. The matrix is 27 x 27, using the disaggregation of Ahmad, Barrett and Coady (1985). Corresponding to each sector in the input-

output matrix, sector-specific value added is produced using capital and urban labor for the

nonagricultural sectors, and land and rural labor in agriculture.[2]

We suppose that each type of sectoral capital is produced via a sector-specific investment

technology that uses inputs of capital and labor to produce new capital. Investment is carried out

by the private sector and is entirely financed by domestic borrowing.

The decision to invest depends not only on the usual investment variables, but also upon

the decision the firm makes as to whether it should pay taxes. This decision determines the

firm's entry into the underground economy. We assume that the firm's decision is based upon a

comparison of the tax rate on capital with the rate of return on new capital. Formally, suppose

that we were in a two period world. Suppose that:

$$\frac{P_{K2}}{1+r_1} \geq t_{K1}$$

that is, the present value of the return on one unit of new capital is greater than the current tax

rate on capital. In this case we assume the investor pays the full tax rate on capital inputs.

Suppose, on the other hand, that:

$$\frac{P_{K2}}{1+r_1} \leq t_{K1}$$

Here the discounted rate of return is less than the tax rate. The extent to which the firm

goes into the underground economy is determined by the gap between the tax rate and the rate of

return to investment. That is, the firm pays a tax rate of $\overline{t}_{K1}$ where:

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[2] See Feltenstein and Cyan (2012) for the specific formulation of this problem, as well as for other details
in the underlying general equilibrium model.

$$\overline{t}_{K1} = t_{K1}\left[1 - \left(\frac{t_{K1} - \dfrac{P_{K2}}{1+r_2}}{t_{K1}}\right)^{\alpha}\right] \tag{1}$$

Here $0 \leq \alpha$ and higher values of α lead to lower values of taxes actually paid. That is, the ratio $\dfrac{\overline{t}_{K1}}{t_{K1}}$ reflects the share of the sector that operates in the above ground economy. Hence α represents a firm-specific behavioral variable. An "honest" firm would set $\alpha = 0$, while a firm that is prone to evasion would have a high value for α.

Banking

Our premise is that banks have no direct way of knowing whether specific firms operate in the underground economy. We assume that banks only care about the amount of capital that they estimate the firm may have. If the firm defaults on its loan, then this represents the best estimate of the amount that the bank could seize. The bank would, presumably, be willing to lend an amount equal to at least the estimated firm capital.

We assume the borrower is required to show the bank his tax returns in order to obtain a loan. There is a single, flat corporate tax rate that the borrowing firm faces. Hence, suppose that T_{K1} represents taxes actually paid by the borrower in period 1. This is known to the bank, as the potential borrower is required to present his tax returns. Thus if the borrower fully complied with his tax obligation, and hence carried out no underground activity, the value of his capital, $\hat{K}_1$, would be given by:

$$\hat{K}_1 = \frac{T_{K1}}{t_{K1}}$$

In this case the bank lends an amount L_1 ,where $L_1 < C_{H1}$, as the bank would not be able to seize the full value of the loan in the case of a default. The situation we have described would, in the case of perfect certainty, have credit rationing when the estimated value of the firm's capital is less than its loan request. If the firm's capital is greater than its loan request, there would be no credit rationing.

Consumption

There are two types of consumers, representing rural and urban labor. We suppose that the two consumer classes have differing Cobb-Douglas demands and endowments. The consumers maximize intertemporal utility functions, which have as arguments the levels of consumption and leisure in each of the two periods. For a discussion of this modeling approach, as well as mathematical details, see Feltenstein and Shamloo (2012).

The Government

The government collects personal income, corporate profit, and value-added taxes, as well as import duties.[3] It pays for the production of public goods, as well as for subsidies. In addition, the government must cover both domestic and foreign interest obligations on public debt. The resulting deficit is financed by a combination of monetary expansion, as well as domestic and foreign borrowing

The Foreign Sector

The foreign sector is represented by a simple export equation in which aggregate demand for exports is determined by domestic and foreign price indices, as well as world income. The specific form of the export equation is:

$$\Delta X_{n0} = \sigma_1 \left[\frac{\pi_1}{\Delta e_i + \pi_{Fi}} \right] + \sigma_2 \Delta y_{wi}$$

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[3] We only consider a central government.

where the left-hand side of the equation represents the change in the dollar value of exports in period i, π_i is inflation in the domestic price index, Δe_i is the percentage change in the exchange rate, and π_{Fi} is the foreign rate of inflation. Also, Δy_{wi} represents the percentage change in world income, denominated in dollars. Finally, σ_1 and σ_2 are corresponding elasticities.

d)   Simulations

In this section we carry out numerical simulations of our CGE model. The model is designed to give some qualitative notion of the implications for the macro economy of tax evasion and entry into the underground economy. Our goal is to calibrate the model to the dynamic path of the Pakistan macro economy, based upon the most recent available sources for the economy's technological and policy parameters.

We use an input-output (IO) matrix given in Ahmad, Barrett and Coady (1985), in which an 87 sector matrix is derived to represent Pakistan's technology for 1981. This has been updated for 1989/90, and we use the coefficients in this updated matrix.[4] This matrix is aggregated by adding rows and columns to generate the 27 sector matrix used for this study. Sectoral value addeds are taken from the national income accounts for 2004 expanded to correspond to the 27 sector IO matrix. We use 2004 as a starting point as our 8 year dynamic simulation is from 2004 – 2011. The production coefficients in sectoral value added functions are Cobb-Douglas and are taken from the IO matrix.

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[4] Unfortunately there is no up to date input-output matrix that is currently available for Pakistan. We have been informed that one is being developed, but it not complete and we do not have access to it. Of course the structure of the Pakistan economy may well have changed since 1990, but we do not have evidence to support or reject such a conclusion. Once the new input-output matrix becomes available, then it can easily be substituted for the old matrix and the simulations and gap estimates can be re-calculated.

The model incorporates personal and corporate income taxes, sales taxes, and import tariffs. Our source for all tax rates is the website of World Tax Rates 2010/2011.[5] For the personal income tax we use the various slabs from 0 to 20 percent. For the corporate tax rate we use 35% of net taxable income of a company. For nonresidents, a 15% rate is levied on the gross amount of royalties or technical service fees, and 30% for other payments under the presumptive tax regime. The standard rate of the sales tax in Pakistan is 16 percent. Note that these are statutory rather than effective rates. The model generates endogenous effective tax rates, which are different from rates generated by single equation estimates.

Exchange rate time series are taken from the Statistics and DWH Department, the State Bank of Pakistan. We use the annual average US dollar foreign exchange rates for the years 2003-2010, as we wish to generate a dynamic macroeconomic path for these years. We assume that the structure of financing of the government budget deficit is an exogenous policy instrument, and we take the 2003-2010 shares from the Handbook of Statistics on Pakistan Economy 2010 (State Bank of Pakistan 2010).[6] We make a similar exogeneity assumption for public and private capital inflows, which are taken from the Table 8.1 of the same source. Our source for the historical series of expenditure by the consolidated public sector is Table 3.7 where we use the shares of GDP table.[7]

Our model incorporates behavioral demand for money that depends upon interest and inflation rates, as well as real income. We use the estimates given in Qayyum (2005). In order to use our model for counterfactual simulations, we first generate an equilibrium using benchmark policy, technological, and behavioral parameters described. The program used to solve for the equilibrium converges to an accurate approximation of a Kakutani fixed point in usually less

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[5] World Tax Rates 2010/2011 "Pakistan Tax Rates." http://www.taxrates.cc/html/pakistan-tax-rates.html
[6] Table 4.2, Summary of Public Finance (consolidated federal and provincial).
[7] http://www.sbp.org.pk/departments/stats/PakEconomy_HandBook/Chap-3.7.pdf

than 20 seconds for the 8 discrete time periods we are currently simulating. We run the macroeconomic model forward for eight years,[8] giving tax rates and public expenditures their estimated values. We also suppose that the central bank maintains a fixed exchange rate, with the rate being fixed at the historical level of each year. Table 1 shows the results of the benchmark simulation. It may be worth making a few remarks concerning the simulated values. First, notice that our model generates moderate rates of growth in real GDP, with an average growth rate of 5.9 percent over the total 8 year period. This approximates Pakistan's actual real growth rate over the period in question. The budget is in deficit for all but 1 year, with an average deficit of 1.1 percent of GDP. This is lower than the actual historical deficit for the period. The simulated interest rate is relatively stable, and averages 7.9 percent, which is in line with Pakistan's interest rate. The trade deficit is relatively stable and averages 2.3 percent of GDP, which is somewhat better than the current level in Pakistan. The annual rate of inflation averages 22.3 percent, which is somewhat higher than the Pakistani average. Finally, sector 4, services and retail trade, operates significantly in the underground economy for all 8 years of the simulation, indicating considerable tax evasion in retail trade. This also possibly corresponds to the Pakistan experience. By the end of the 8 years of the simulation, the sector is under-reporting income for tax purposes by 31.5 percent.

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[8]In practice, we take 2004 as the base year. By this we mean that initial allocations of factors and financial assets are given by stocks at the end of 2003. We have data for fiscal and other policy parameters for the next 8 years, that is, through 2011.

Table 2. Base Case

Period	2004	2005	2006	2007	2008	2009	2010	2011
Nominal GDP 1/	100.0	137.8	133.4	181.2	314.1	475.3	538.3	785.6
Real GDP 1/	100.0	117.4	113.5	119.7	131.3	142.3	144.3	149.6
Real GDP growth rate 3/		17.4	-3.3	5.4	9.7	8.4	1.4	3.6
Inflation 3/		17.4	0.1	28.9	58.0	39.7	11.6	40.8
Price Level 1/	100.0	117.4	117.5	151.4	239.2	334.1	373.0	525.3
Nominal interest rate 3/	6.9	10.5	3.6	3.6	8.4	13.1	7.7	9.7
Budget surplus 2/	-1.4	-1.3	-1.6	-1.8	1.3	-1.2	-0.9	-2.2
Trade Balance 2/	-3.7	-2.6	-2.0	0.0	-4.3	-2.0	-2.6	-1.1
Import Duties 2/	2.0	2.1	2.2	2.2	2.1	2.1	2.2	2.2

Real return to		**Share of Sector in Legal Economy**			
		2005	2007	2009	2011
K1 1/ 4/	100.0	100.0	100.0	100.0	100.0
K2	100.0	100.0	100.0	100.0	100.0
K3	100.0	100.0	100.0	100.0	100.0
K4	100.0	3.7	5.9	27.0	58.5
K5	100.0	100.0	100.0	100.0	100.0

1/ Normalized to period 1 of the base case.
2/ As a percent of GDP.
3/ In percent.
4/ The capital types are specific to broad sectors of the input-output matrix. The 5 capital types are:
K1 = Mining
K2 = Manufacturing
K3 = Electricity, gas, construction
K4 = Services, retail trade
K5 = Public administration, health, education

Our model helps us to identify those sectors that are underperforming from a tax point of view. We therefore use the model to carry out a sectoral estimate of the tax gap. Here the predicted outcomes of the general equilibrium model for 2010, assuming full compliance, are compared with actual tax revenues collected. That is, we set the "honesty" parameter for each sector at 0. This is the parameter α in equation (1). The general equilibrium model then generates a path for tax collections for the 8 years of the simulation, and we choose the predicted

collections for 2010. These are then compared with actual tax collections for 2010 for selected sectors, as well as for the aggregate economy and the manufacturing sector. The aggregate results are given in the Table 2 below. They indicate that, on the level of the overall economy, there is a tax gap of about 58 percent, while in the manufacturing sector the gap is approximately 53 percent. As might be expected from the general equilibrium model, capital intensive sectors such as iron and steel, and oil and gas, have smaller gaps than do less capital intensive sectors such as finance and insurance, or hotels and restaurants. These calculations should help in the measurement of the overall problem, as well as to identify those sectors where improvement is most needed.

It may be useful to add a few remarks about the absolute values of these gap estimates. Recall that the sectoral definitions of the general equilibrium model are based upon the 87 sector Pakistan input-output matrix. These sectors are, in turn, based upon national income accounts value added definitions. These sectoral definitions are not exactly the same as those in the actual tax collection tables which we use for the gap estimates. Thus, for example, the national income account definition of Finance and Insurance may be broader than that used by the tax authorities.

Accordingly, the general equilibrium model would generate greater expected tax revenue for Finance and Insurance, assuming perfect compliance, than would be reflected in actual tax collection data. Hence the estimated compliance gap would be relatively large, as we see in the Table. Of course the opposite could also be true, that the national income account definition could be narrower than the tax definition, leading to some under estimations of particular gaps. Accordingly, it is best to look at broad sectors, such as the overall economy, manufacturing, or retail sales, for example, for absolute values of gaps as there is a closer comparison between national income account and tax collection definitions for these categories. For more narrowly

defined sectors, it is best to look at the gap estimates as reflecting relative (compared to other sectors) rather than absolute gaps.

Table 2. Tax Gaps by Selected Sectors in percent 1/

Sector	Gap
Mining & Quarrying	-96.9
Manufacturing	-52.5
(of which)	
1. Chemicals	-67.5
2. Automobiles	-48.3
3. Cigarette & Tobacco	103.4
4. Iron and Steel	-10.5
5. Oil and gas	-25.7
6. Paper & Paper Board	-53.2
7. Textile	-59.2
8. Edible Oil	75.2
9. Cement	-49.0
10. Sugar	-91.2
11. Pharmaceuticals	-46.9
12. Fertilizer	-23.0
Telecom	-81.3
Wholesale and Retail Trade	-73.4
Finance and Insurance	-93.3
Hotels and Restaurants	-85.3
Other	-53.8
Total Economy	-58.3

1/ A number of manufacturing sectors have been excluded from the disaggregation.
They are included in the category "other". Other sectors that are not included in the terms of reference, but for which it is possible to calculate gaps, have been included.

IV.   Pakistan Micro Simulation Model (MSM)

The MSM that serves as the second piece of the integrated model that is under development is based on a number of micro data files from the Pakistan. The MSM allows very detailed calculation of income and consumption taxes (at any level of government) and also provides a means to analyze the distributional effects of these taxes on Pakistani households by income level, region of the country, urban-rural split, etc. and therefore provides a level of detail that cannot be provided by the CGE model. Sectoral analyses can also be developed. MSM

models are very useful for nuanced changes in tax policy such as simple rate changes, changes to deductions, and exemptions. CGE models are not typically as adept at these types of changes because the data are more aggregate/macro-based. In such cases, MSM models can be used to estimate the change in effective tax rates which can be feed into the CGE model. If those changes are relatively small, the CGE model may not pick up a measurable change in macro aggregates. As noted above, because of the micro-level data, the MSM might also be used to estimate behavioral effects of tax changes such as labor or savings behavior, and these changes could be fed into the CGE model. Or, the MSM could be used to establish the aggregate base data on labor, income, employment, etc. which could then serve to calibrate the CGE model. In the future, these various integrations will be tested using the Pakistan models presented here and we will be analyzing whether or not there are perceptible differences in policy simulations from the various integrated models. Ex ante, we have no theory that suggests any one integration model will provide more accurate estimates of policy effects or more reliability welfare effects, etc. That is a matter of future research.

In the current MSM, the follow micro data sets are used: the Pakistan Household Integrated Economic Survey (HIES), the Pakistan Labor Force Survey, and a special sample of tax returns from Federal Board of Revenue (FBR).[9] The current MSM is based on 2004-05 data files.

The HIES includes data for 14,708 households. The survey asks very detailed questions about expenditures, income, employment, family situation, and housing. We use the weight

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[9] Until 2007, the income tax returns are referred to as "R" forms due to the naming of the specific forms. The "IT" form series has replaced the "R" form series and these new forms are much more data entry and taxpayer friendly. For details of the MSM model, see Wahid, U. and S. Wallace (2008). "Incidence of Taxes in Pakistan: Primer and Preliminary Estimates." .

provided to us by the Federal Bureau of Statistics in the analysis. Once the observations are weighted, we have a population total of 19,288,310 households.

The HIES is the key data set for the MSM. We use total income information and information on the distribution of expenditures by detailed type along with the demographic data of the households. The overall level of expenditure is substantially less than reported in the national accounts. This poses a difficult problem in any modeling, but in particular for the potential integration of the CGE and MSM. Currently, the HIES data are reweighted to reflect national totals of expenditure.

From the FBR, we have tax return micro data which allows us to "layer" a pattern of compliance on the HIES data. Since the HIES data provide detail about employment (formal, informal, government, etc.), a module within the MSM calculates tax liability. The calculated tax liability is then matched to HIES observations, with the expected small number of matches, representing compliant taxpayers.

Finally, we use the Pakistan Labor Force Survey (LFS) 2005-06 micro data file as another check on non-compliance. The LFS is a detailed micro data file with 32,744 households and individuals within each household. The data contain detail regarding the type of employment and average weekly or monthly income by employment type for paid employees only (not self-employed and other workers). The LFS is thought to be a more thorough data set for analyzing wage income for paid workers. The HIES and LFS include income from all individuals and households—that of compliant and non-compliant taxpayers as well as taxpayers below and above thresholds. As such, both of these data sources should provide a potential level of tax liability in the country. To work with both of these files, we deflate the LFS by 9 percent to reflect the 2004-05 level of the HIES data. If we were starting with tax return data as our base

data source, we would have to impute non-compliers to the income distribution so that we had a full picture of the tax burden on all individuals and households in Pakistan.

Because our data are so detailed, we can analyze the distribution of tax burden from the more appropriate measure of "comprehensive income" which incorporates the theoretical finding that taxes affect returns to capital and labor. The appropriate distributional analysis would use an income measure that represents a counterfactual—what income returns would be without the taxes—to provide a measure of tax burden. One obvious example is the case of wage income. Wages are reported net of taxes. If we assume that the incidence of the salaried individual component of the income tax is on wage earners, we need to "gross up" our income measure (measured via consumption expenditures) to reflect the pre-tax level of wage income (as reported consumption expenditures will obviously not include this tax impact on wage income). The same is true of taxes on capital (from the capital income tax, corporate income tax, and property taxes).

To operationalize the MSM model, we effectively create a tax system via a computer program (in SAS or STATA), and calculate tax liability for each household (income and consumption taxes). If we apply the tax calculator to the entire database, we have an estimate of potential tax liability. We know that tax evasion is rampant in Pakistan, so as noted above, we flag non-compliant taxpayers by matching tax return data with the estimated liabilities. In the case of consumption taxes, we have FBR data on collections by type of product and by region of the country. Based on these data, we know for which consumption items and regions actual tax payments are less than our MSM estimated liabilities. However, unlike the income tax information, we do not know where in the income distribution the consumption tax evasion is concentrated. In the current model, we assume that the consumption tax evasion is uniformly

distributed in the population according to their consumption of specific taxable items (which we have in detail in the micro data). A companion corporate model is also developed using income tax returns from FBR. The corporate model is utilized mainly to provide estimates of changes in effective tax rates by sector, which is possible because of the detailed tax calculator available in the corporate MSM. A typical tax incidence analysis would use the output from the corporate MSM to distribute the change in the corporate tax to individuals based on a sophisticated set of assumptions regarding the incidence of the corporate tax on labor and capital (Wahid and Wallace 2008).

The model can be used to simulate a number of alternative tax policies. The changes are calculated within the MSM, holding behavior constant (including compliance). Turning behavior "on" moves the MSM from static to "micro dynamic" as noted in the introduction. The static MSM provides detailed output regarding the effective tax rate by income level, sector, etc., which may be used as input to the CGE model.

For purposes of illustration, the static version of the MSM model was used to analyze the impact of reducing the corporate income tax and increasing the consumption tax rate (across the board). A 10 percent reduction in CIT revenue would cost Rs 20 billion (2006-07 levels). The level of reduction could be achieved through a reduced corporate tax rate or a higher threshold, among other items.

To achieve an increase in GST revenue of Rs 20 billion would require a 6.5 percent increase in consumption tax revenues. This would yield an increase in the effective tax rate of about 6.4 percent relative to GDP and in the statutory rate of slightly over one percentage point. This type of tax reform would reduce the burden on the upper income via the reduction in

corporate income tax and at the same time increase the "across the board" take from the increased consumption tax.

Based on MSM results, the "winners" are those individuals in the top decile, whose total effective tax rate falls by about 0.17 percentage points—or about 1.3 percent reduction in the effective tax rate. The households in all other deciles would see an increase in tax burden of between 0.08 to 0.11 percentage points. In this option, the lowest income deciles see the largest increase in tax burdens. In the final section, we use the MSM output for this policy change to provide a starting point for the CGE model, and analyze the results. This top down model is one of the integrated models that can be analyzed and in the future, we will be analyzing additional alternatives.

V.   Conclusion

Computational general equilibrium models (CGE) and micro-simulation models (MSM) each have their own sets of strengths and weaknesses. Both have been widely used for the analysis of fiscal policies in developing countries, and many attempts have been made to link the two models, thereby combining their relative strengths. We have surveyed a broad literature uses a variety of approaches to apply linked CGE and MSM models to analyze fiscal policies, in particular taxes and tariffs, in developing countries. We conclude that the "top down" approach, in which the aggregate outputs of the CGE model feed into the MSM, is the most commonly used. Nonetheless, a "bottom up" approach, in which the MSM generates estimated parameters, such as effective tax rates, which are then used as inputs to the CGE, may also be quite useful.

We have then developed CGE and MSM models of Pakistan, both of which have been used to analyzed tax compliance and the general effectiveness of the Pakistan tax code. The two models have not, at this stage, been formally linked and we are working on such a linkage as part

of future research. As an example of how a bottom –up link might work, we could take the simulation given in the MSM study, reducing the CIT by 10% and thereby changing the effective rate of tax/gdp from 3.27 percent to 2.94 percent. We would then compensate by increasing the effective consumption tax rate from 3.03 to 3.2 percent. These new effective tax rates would then enter the CGE model as input parameters and the CGE model would track the dynamic impact on the macro economy.

This chapter is focused on two important models for policy analysis—the CGE and MSM. In general, MSM are useful for relatively small policy changes—changes in tax rates that will have small impacts on behavior (savings, labor, investment, etc.), changes in exemptions, credits, and deductions, and in cases where distributional analyses are critically important. CGE models are most useful for major policy changes where we expect substantial changes in effective tax rates which in turn impact the level of output in the economy, employment, savings, etc. In some cases, choice of the model is a function of data availability as micro-level data may not be available in certain countries. Ultimately, integration of the two models enables answers to all of the important policy questions—employment, output, savings, distribution of the tax burden, and revenue impacts. We continue to investigate the integration of CGE and MSM and identification of a metric to evaluate whether or not there is an optimal integration—be it top-down, bottom-up or other.

Table 1: A Comparison of Alternative Approaches

Approach	Advantages	Disadvantages
Top-down	- Richness in terms of household behaviors that can be modeled (compared to the top-down-RHG, the income distribution function and the fully-integrated approaches).	- The coherence between the macro and micro models is not guaranteed. - The feedback effects of household behaviors are not taken into account in the CGE model.
Top-down with representative household groups	- Simplicity (fewer resources in terms of data, time, and skill, compared to alternative approaches that are not based on representative household groups).	- It does not account for heterogeneity among agents within household categories (all individuals pertaining to the same household category will be subject to the same impact estimated by the CGE model). - The feedback effects of household behaviors are not taken into account in the CGE model.
Income distribution function approach	- Simplicity (fewer resources in terms of time, skill, and data – it requires only the set of parameters estimated for each within-group distribution of income).	- The within-group distribution of income is assumed to be fixed across simulations (only the distribution of income between groups of households and the overall distribution of income change across simulations). - Strong assumption that one income distribution represents all groups of households.
Top-down/bottom-up	- It takes into account the feedbacks of households generated by the micro model back into the CGE model	- The results may change in a fundamental way depending on how feedbacks from the MSM model are imposed on the CGE model.

	- There is no need of adjusting the micro data to the national accounts and there is no need of balancing income and expenditure, as required by the fully-integrated approach. - It imposes fewer limits on microeconomic household behavior, compared to the fully-integrated approach.	- Data inconsistencies between the micro and macro datasets can affect results seriously. The researcher may be unable to distinguish whether the resulting changes are due to feedback effects or due to data inconsistencies.
Fully-integrated	- It is able to capture the interaction between policy reforms and individual responses. It is able to capture individuals' feedbacks to the general economy.	- The reconciliation of the micro data with the macro data is a requirement and may be difficult. - More limited in terms of household behaviors that can be modeled than the TD and TD/BU layered approaches. Certain types of equations that are commonly included in a behavioral model are not easily modeled within standard CGE modeling softwares.

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