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Urban CGE Modeling: An Introduction

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Abstract

Cities are usually confronted with a large variety of economic development choices. With growing environmental concern as well as rising income and wealth inequalities, assessment of the impacts of such choices is likely to gain in importance. Consequently, the demand for adequate assessment tools will grow. Computable general equilibrium (CGE) models analyze issues of resource allocation and income distribution in market economies. They have become a widely accepted tool for policy assessment over the past two decades but are currently still primarily a field for specialists. This is particularly distinctive in the case of urban CGE models, which are the focus of this paper.

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1 Introduction

Cities are usually confronted with a large variety of economic development choices. With growing environmental concern as well as rising income and wealth inequalities, assessment of the impacts of such choices is likely to gain in importance. Consequently, the demand for adequate assessment tools will grow. Computable general equilibrium (CGE) models analyze issues of resource allocation and income distribution in market economies. They have become a widely accepted tool for policy assessment over the past two decades but are currently still primarily a field for specialists. This is particularly distinctive in the case of urban CGE models, which are the focus of this paper.

The paper is motivated by what appears to be a “dead spot” between (urban) economists on the one hand and (local) policy makers on the other. Clearly, such a situation is a shortcoming on the part of education and research institutions; a twofold shortcoming, in fact. First, CGE modeling on the whole is given fairly little attention in classroom settings. Tuition tends to focus on abstract forms and existence proofs, the practical relevance of which is little at best to non-specialists (Peng, 2009). Second, CGE-oriented research is predominately concerned with national and regional issues. Consequently, most CGE models focus on relatively large geographical areas and cannot capture the uniqueness of cities and towns (Schwarm & Cutler, 2003).

Bearing the above in mind, this paper shows how the spatial structure and development of real-world cities can be analyzed and assessed in the framework of a CGE-model. The paper is organized as follows: Section 1 briefly describes the development of urban economic models and presents a simple model of the urban housing market. Section 3 illustrates how urban issues raised in such models can be dealt with in a CGE framework. Section 4 summarizes and concludes with an outlook for future research.

2 Urban Economic Models

This section briefly describes the development of urban economic models and presents a simple model of the urban housing market. It is shown how the model gives rise to a number of spatial profiles that can be used to analyze the internal structure of a city as well as make comparisons across cities.

2.1 Brief Historical Overview

Urban economic models are tools for analyzing cities in terms of spatial structure, and by virtue of this analysis to evaluate development policies targeting spatial profiles such as housing prices, structural densities or city size. They are based on standard microeconomic theory, more specifically on location theory, the advent of which is closely associated with von Thünen (1826). It was not until the works of Alonso (1964), however, that von Thünen’s concept was applied to urban areas and

interpreted in purely such contexts. From this evolved an independent, highly specialized discipline, today referred to as urban economics.

Urban economic theory is based on Alonso's (1964) theory of the urban land market, exemplified in the monocentric city model. The key insight of this model is that urban land prices vary with accessibility to the city center, thereby generating a distinct spatial pattern of building height and housing consumption, namely taller buildings with smaller dwellings (less floor space) around the center and shorter buildings with larger dwellings (more floor space) in the suburbs. Because these broad features can be observed in many real-world cities, Alonso's model has been very successful.

However, due to a number of relatively unrealistic assumptions, Alonso's model cannot predict urban morphology on a more detailed level. This limits its use for policy analysis. In the past decades a lot of research effort has been devoted to adding greater realism to the monocentric-city model. These theoretical advances have, along with ongoing progress in data availability and computer technology, aided real-world applications. The CGE approach is particularly appealing because it retains the basic theoretical structure but allows for more detail and complexity than an analytical model.

The following subsection lays out the theoretical structure of the traditional monocentric city model. The discussion follows Brueckner (1987), where the reader is referred to for a more comprehensive treatment of the model. In unifying the Mills (1967) and Muth (1969) versions treating land as an intermediate input in the production of housing, Brueckner's model is slightly more realistic than Alonso's approach, albeit retaining its predecessor's simple framework. This appears useful for the current undertaking, where fundamental mechanisms rather than realism-enhancing details are of interest.

2.2 The Monocentric-City

Similar to Alonso's (1964) model, Brueckner's (1987) model presupposes a monocentric and circular city with a central business district (CBD), where residents work and earn identical incomes. Travel to and from the CBD is unimodal and occurs on a dense radial road network. All land is assumed to be homogenous and owned by absentee landlords. There are two types of economic agents: Residents, who consume housing (floor space) and a composite non-housing good and housing producers, who supply housing (floor space). Consumers have a set of preferences resulting in demand functions for each of the two commodities. Market demands are the sum of each consumer's demands. Commodity markets depend on all prices and Walras' Law holds, i.e. the total value of consumer expenditures equal consumer income at any set of prices (no saving). Equilibrium in this model is characterized by a set of prices and levels of production such that market demand equals supply for all commodities (market clearing condition). Since producers are assumed to maximize profits

subject to a constant returns to scale production function, they break even at the equilibrium price (zero-profit condition).¹

To see how the model can be used to analyze the internal structure of a city it makes sense to formalize the above. Starting with the demand side, residents choose c and q to maximize utility subject to a budget constraint, i.e.

$$\max_{c,q} v(c, q) \text{ s. t. } c + pq = y - tx$$

where c is consumption of the composite non-housing good (chosen as numeraire), p is the price of one unit of housing (floor space), q is consumption of housing (measured in units of floor space), y is the common income, x is distance to the CBD and t is commuting cost per unit of distance.

Because consumers are identical, the urban equilibrium yields identical utility levels for all residents. Using the budget constraint for substitution of c in the utility function, the requirement that the maximized utility level equals u can be written

$$\max_q v(y - tx - pq, q) = u.$$

The above expression is composed of two separate statements. First, since consumption of housing (floor space) depends on housing (unit) price the first-order condition for the choice of q is

$$\frac{v_2(y - tx - pq, q)}{v_1(y - tx - pq, q)} = p$$

(subscripts denote partial derivatives). Second, the requirement that the resulting consumption bundle must afford utility u is

$$v(y - tx - pq, q) = u.$$

The simultaneous system composed of the two equations above yields solutions for the endogenous variables p and q , both of which depend on the parameters of the model, namely x , t , y and u .

Turning to the supply side, the housing industry's production function is given by

$$Q = H(N, l)$$

where Q is housing (floor space) output and N and l are capital and land inputs respectively. Since a constant returns to scale production function is assumed, the function can be written in intensive form

$$h = h(S)$$

¹ Because the individual demand functions are assumed to be homogeneous of degree zero, i.e. if prices and income are doubled, the optimal quantities demanded do not change, while profits are by definition linear in prices, only relative prices are of significance in the model; the absolute price level has no relevance for the equilibrium outcome.

where $S \equiv N/l$ equals capital per unit of land. S is termed structural density and is an index of building height. Housing producers maximize profits subject to their production technology. With p representing the price of one unit of housing (floor space) – producers are price takers – and r and i denoting the cost of one unit of land and capital respectively, profit per unit of land can be written

$$\Pi = ph(S) - (r + iS).$$

For producer profits to be spatially uniform throughout the city (zero-profit condition), land rent must vary. Every profit-maximizing producer's behavior can therefore be described by

$$\max_S \{ \Pi = ph(S) - (r + iS) \}$$

with the first-order condition for choice of S and the zero-profit condition being

$$ph'(S) = i$$

$$ph(S) - iS = r$$

respectively. Recalling that p is already a function of x , t , y and u , the last two expressions can be used to determine land rent r and structural density S as functions of the same variables as well as i . These functions describe the relationships between the endogenous variables housing price, housing quantity, land rent and structural density and the parameters of the model, i.e. distance to the CBD, commuting cost, income, cost of capital and overall utility level.

If the overall utility level were known, these functions could be used to determine equilibrium housing and land prices at all locations in the city, as well as other spatial profiles. Before addressing this issue in more depth it is worthwhile to bring the nature of the relationships between the endogenous variables and the parameter x to mind because they provide key insights into the internal structure of the city. They are stated as follows:

$$\frac{\partial p}{\partial x} < 0, \quad \frac{\partial q}{\partial x} > 0, \quad \frac{\partial r}{\partial x} < 0, \quad \frac{\partial S}{\partial x} < 0.$$

Thus, housing prices, land rents and structural density all decrease with increasing distance to the city center whereas housing quantity per consumer increases. The explanation behind this spatial pattern on the part of residents is that those living further away from the center are compensated for their commuting expenses with cheaper housing prices, which in turn enables them to consume more housing (floor space). For housing producer profits to be equal throughout the city (zero-profit condition), land rent must decrease with increasing distance to the CBD. This decline in land rents reflects the decline in housing prices and effectively alters the optimal capital-to-land input mix from more capital intensive to less capital intensive forms of land use. Thus structural density, i.e. building height falls with increasing distance to the city center.

An additional variable of interest at this point is population density, denoted D and written

$$\frac{h(S)}{q}.$$

Recalling that $\frac{\partial q}{\partial x} > 0$ and $\frac{\partial S}{\partial x} < 0$, it follows that $\frac{\partial D}{\partial x} < 0$; since housing quantity increases, while building height falls with distance to the city center, more distant locations contain fewer dwellings and hence fewer people per unit of land.

Apart from analyzing the internal structure of a city, the model can also be used to make comparisons across cities. This involves two additional conditions that characterize the overall equilibrium of the city. The first condition ensures that housing producers secure the land used in the production of housing. This translates into the requirement that land rent must equal the exogenous agricultural rent at the edge of the city, which is why in models of this type urban structure is ultimately the result of competing uses of land. Recalling that land rent is already a function of x , t , y and u , the first equilibrium condition can be written

$$r(\bar{x}, y, t, u) = r^a$$

with \bar{x} and r^a denoting distance to the urban-rural boundary and agricultural rent respectively. Consequently, land rent exceeds agricultural rent inside of \bar{x} whereas agricultural rent exceeds land outside of \bar{x} .

The second equilibrium condition guarantees that the urban population fits inside \bar{x} . This condition is formalized by letting θ equal the number of radians of land available for housing at each x , with $0 < \theta \leq 2\pi$. In this case the population of a narrow ring with inner radius x and width dx equals approximately $\theta x D(x, y, t, u) dx$. The condition that the urban population L fits inside \bar{x} can then be written

$$\int_0^{\bar{x}} \theta x D(x, y, t, u) dx = L.$$

The urban utility level u has so far been treated as a parameter. This, however, need not be the case. If the city is closed to migration, the urban population is given and u is determined endogenously together with \bar{x} by solving the two equilibrium conditions simultaneously. In this case u and \bar{x} are expressed as functions of the parameters L , r^a , y and t and all equilibrium spatial profiles can be determined. If the city, on the other hand, is open to migration, u is exogenous. It represents then, the prevailing utility level outside of the city that is achieved within the city through costless migration. Consequently, urban population is endogenous. In this case the procedure is recursive because \bar{x} has to be expressed prior to L . Once this solution is obtained, however, all equilibrium spatial profiles can again be determined.

One of the most interesting features of analytical models is their comparative static properties. In general, comparative static analysis is concerned with how a change in parameters affects economic outcome. Brueckner (1987) provides a comprehensive comparative static analysis of the model outlined above, which he concludes with reflections on whether cities in a national economy should be viewed as open or closed. Based on casual empiricism he makes the case for both. This suggests that careful attention must be paid to actual conditions when drawing conclusions from the model.

What also shouldn't be overlooked are the model's unrealistic features. These include the assumption of a monocentric as opposed to a polycentric city, homogeneous rather than heterogeneous residents, the general neglect of the urban transportation system by treating commuting cost as exogenous instead of endogenous, its focus on a single housing attribute (floor space) as opposed to multiple attributes, the absence of a public sector and its suppression of history, i.e. time. Given the theoretical advances, these problems have in general been overcome. Analyzing policies in analytically more challenging frameworks than the one presented here, however, seldom yields unambiguous solutions. This is where numerical approaches, to which the discussion now turns, enter the stage

3 The CGE Approach²

This section describes the CGE approach and explores how urban issues can be captured in the framework of a CGE model. In general, applied CGE modeling is concerned with converting the theoretical concept of Walrasian general equilibrium into a realistic model of an actual economy so that policy options can be evaluated. The model outlined above represents such an abstract concept, however extended by a spatial dimension. Because the implementation of a CGE model typically involves a number of sequential steps irrespective of whether the underlying theoretical structure considers space or not, a general outline of the modeling process is presented first. The subsequent sections then turn to individual components of the outlined modeling process and highlight aspects that appear to be particularly relevant when attempting to build an urban CGE model.

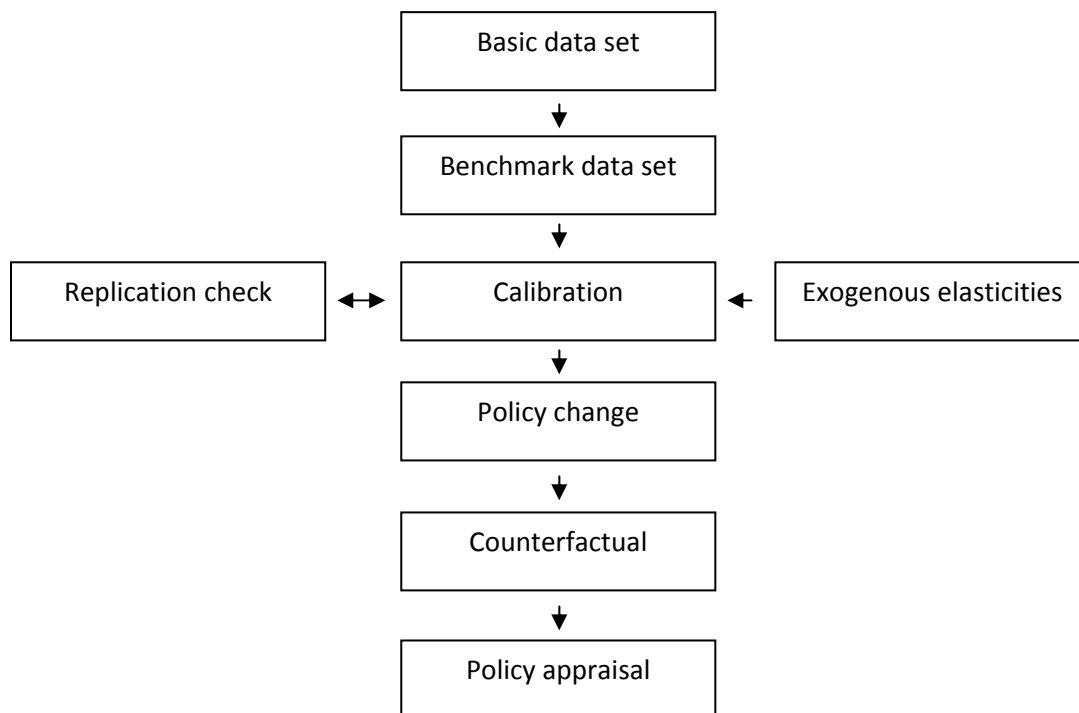
3.1 The CGE Modeling Process

As illustrated in Figure 1, a typical CGE modeling process begins with basic data for an economy for a single year or an average of years. This data is usually not consistent with the conditions necessary for an economy to be in equilibrium (e.g. output is not equal to consumption), which is, however, what a CGE model generally assumes. Thus, the data has to be adjusted. This is often carried out in the framework of a social accounting matrix (SAM). The resulting data set is termed "benchmark data set". Once the underlying data set has been constructed, the calibration procedure begins. This

² This section draws heavily on (Shoven & Whalley, 1984).

involves choosing the functional forms that describe substitution possibilities available to firms and households in the economy under consideration. The model is then used to select functional parameters that support the benchmark data. Depending on the functional forms chosen, this procedure may require exogenously specified elasticity values because the benchmark data, being based on a single year's data or a single observation represented as an average over a number of years, only give price and quantity observations associated with a single equilibrium. The typical source for those elasticity values are literature estimates. Upon receipt of the elasticity values the benchmark data can be used to identify all other functional parameters of the model. If the model is correctly specified, it will reproduce the initial benchmark as an equilibrium solution using the calibrated function parameter values.³ These parameter values can then be used to solve for alternative equilibria. Such alternative equilibria are the result of a considered policy change and are termed "counterfactual". Policies are assessed by comparing the benchmark to the counterfactual equilibrium. This exercise can be thought of as the numerical counterpart of comparative static analysis mentioned above.

Figure 1: A typical CGE-modeling process⁴



³ The replication check represents an accuracy test of the applied computer code; if it fails a programming error has occurred and the coding has to be rewritten.

⁴ This chart is an adaptation from Shoven and Whalley's (1984, S. 1019) flow diagram of a typical CGE model.

3.2 Basic Data

As indicated above, CGE modeling is dependent upon data. This is precisely what makes a CGE model reflective of a real economy. Basic data is usually derived from national accounts, household income and expenditure samples, input-output (I-O) tables, tax statistics, trade balances and balance of payments. It is clear that if the underlying model has a spatial dimension, additional data sources such as land parcel records, for example, will be required.

Unfortunately most of the data sources that are typically used for CGE models are of little immediate usefulness to urban CGE models because the data they contain is not disaggregated to the urban level. National accounts and I-O tables are particularly unfortunate cases in point, considering their relevancy for SAMs. In general, there are three solutions to this problem. First, the required data can be collected by means of empirical surveys. A presumably less expensive but also less accurate solution is compiling the required data from available published sources via non-survey methods. Finally, some hybrid of the two extreme approaches can be pursued. Morrison & Smith (1974) have evaluated several non-survey input-output techniques at the small area level. In their evaluation they also included the semi-survey RAS-procedure⁵, which they found to produce “results far superior to all of the other methods tested” (Morrison & Smith, 1974, S. 13).

3.3 Social Accounting Matrix (SAM)

A SAM is by definition a micro-consistent benchmark data set that mirrors all relevant economic transactions of an economy (OECD, 2003). The economy can be that of a nation, a region or even smaller geographical areas such as a city or town. The principal objective of a SAM is the identification of monetary flows from sources to recipients within a disaggregated account. The scope of disaggregation, i.e. how many groups of economic actors are considered, and the degree of disaggregation within a group of actors depend on the availability of data.

The choice of actors is what distinguishes a SAM from both traditional accounts and an I-O matrix. In general, a SAM typically considers production sectors, households, factors of production, and institutions. Each of these broad groups is further disaggregated. The SAM framework used for the Fort Collins CGE model outlined by Schwarm & Cutler (2003), for example, considers seventeen productive sectors, four additional housing sectors, six specific types of households, eight labor groups and a public sector composed of a federal and a local level which is further divided into five categories. In this particular model household groups are differentiated from one another by level of income which makes it possible to assess income distribution effects. It appears noteworthy to point

⁵ The RAS-procedure is a diagonal similarity scaling algorithm developed by Stone (1961) and Stone & Brown (1962) cit. in (Minguez, Osterhaven, & Escobedo, 2009). It is used in input-output analysis to adjust the entries of a large matrix to satisfy consistency requirements.

out that it can be more appropriate to differentiate households by other characteristics such as age, occupational skill or leisure preferences. Assessing policy induced labor supply effects would be a case in point.

As the term suggests, a SAM is constructed in matrix fashion, with columns representing buyers (expenditures) and rows representing sellers (receipts). It is balanced in the sense that all expenditures made by a buyer equal all income received by the corresponding seller; hence the term “benchmark”. Figure 2 illustrates a SAM framework. The production sectors combine intermediate inputs and primary factors of production which creates value added (income) distributable to corporations and different types of households. Household incomes generate private consumption and investments/saving. Government revenue is generated from direct taxation of household and corporate incomes and from indirect taxation and used to cover public expenditure and investments. Trade linkages can be included as well.

The construction of a SAM is quite challenging because for a SAM to be self-balancing, the data has to be arranged in a logical consistent manner. As indicated above, the data used for CGE modeling typically stems from various sources and therefore considerable adjustments usually have to be made. To ease the workload Schwarm & Cutler (2003) recommend using a series of side worksheets. These worksheets are linked to one another and contain the original data extracted from the various sources as well as all the calculations and alignments made so that when they are linked to the SAM, the SAM automatically balances itself.

Figure 2: A SAM framework⁶

	Commodity (1)	Factors (2)	Households (3)	Government (4)	World (5)	Totals (6)
Commodity (1)	Intermediate Inputs		Consumption and Investment	Consumption	Exports	
Factors (2)	Value Added				Foreign Value Added	
Households (3)		Distribution of Value Added	Savings	Transfer Payments	Foreign Transfer and Savings	
Government (4)	Use and Sales Taxes		Income and Property Taxes	Inter-Gov Transfers		
World (5)	Imports					
Totals (6)						

⁶ As illustrated by Schwarm & Cutler (2003, S. 137).

Schwarm & Cutler (2003) use five worksheets covering I-O data, wage data, land data, household data and data concerning local tax revenues and expenditures as well as a synti worksheet which assigns labor, land and capital to the resident households. The wage data worksheet is particularly interesting because it relates commuting in and out of the city to internal and external wage rates. Commuting is thus accounted for endogenously; it is the result of the attractiveness of working in the city versus the rest of the economy.

3.4 Functional Forms

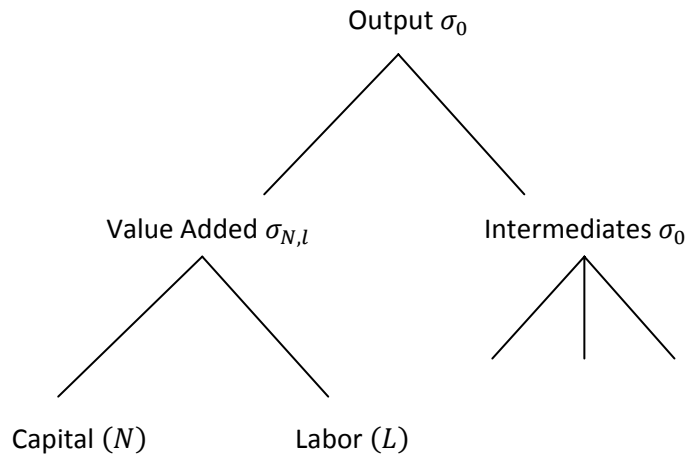
CGE modeling requires utility and production functions that describe substitution possibilities available to households and firms in the economy under consideration. If additional economic actors such as a public sector are introduced, their substitution possibilities have to be specified as well. In a CGE model provision of public goods is usually modeled similar to households, i.e. the (federal/local) government maximizes utility by consuming public goods that are privately produced. Schwarm & Cutler (2003) take a different approach in the sense that the five local public sectors under consideration are modeled such that they hire labor and purchase inputs and services from the productive sectors but are not profit maximizers. Alternatively, a service providing public sector can be considered by letting the public good enter the utility function of the households. A theoretical general equilibrium model adopting this option can be found in Turnbull (1988).

The chosen functional forms have to be adequate from a theoretical and manageable from a practical point of view. The general approach is to select the form that best allows key parameters such as income or price elasticities to be incorporated but can be traced analytically. For the latter reason relatively simple functions such as constant elasticity of substitution (CES), Leontief or Cobb-Douglas functions are common in CGE models. CES functions are used particularly often because they have convenient mathematical properties⁷ and are less restrictive than Cobb-Douglas or Leontief functions with regard to elasticities.

Functions of the type mentioned above can be used to build very complex structures. This is done by nesting them. In general, a nested function is a function defined inside another function. Because this enables the use of multiple elasticities, CGE models often employ nesting structures. Figure 3 illustrates a nested two-stage production structure in which value added is a Cobb-Douglas composite of capital and labor, intermediate inputs are used in a fixed-proportion Leontief production function for each industry and commodity output is in fixed proportions of intermediate inputs and value added.

Figure 3: Nesting structure

⁷ Linear homogeneity, positive, but diminishing marginal returns.



The Fort Collins CGE model outlined by Schwarm & Cutler (2003) is one of the first models to fully model the interrelatedness of economic sectors at the city level. It does this by employing a nesting structure for both the demand as well as the supply side. The production technology in the seventeen productive sectors under consideration is represented by a two-stage production function with a nesting structure similar to the one described above, i.e. primary factors, i.e. land, labor and capital are combined using a Cobb-Douglas function and intermediate inputs are used in a fixed-proportions, Leontief production function with intermediate demand treated as a composite of imported and domestic goods using the Armington (1969) elasticity. The output – a composite non-housing good – goes into domestic supply and export according to a constant elasticity of transformation (CET) function. Consumer preferences are represented by a CES utility function and consumers maximize utility subject to a budget constraint that equals income from primary factors less taxes, but with private and governmental transfers added. The resulting secondary income is allocated to investment (saving), net transfers to the outside economy, housing and the composite non-housing good, treating local and imported commodities as imperfect substitutes.

3.5 Calibration

Calibration is a technique by which parameter values for the functional forms employed in CGE models can be selected. It is a more widely used method than stochastic estimation because the latter has the disadvantage that it requires an unrealistically large number of observations when models are complex as well as time series data that are often not available for key variables. However, serious objections can be raised with regard to the calibration method as well, primarily because it relies on a single year's data with the result that the model will be strongly influenced by whatever stochastic anomalies were present that year. Also, the benchmark year is assumed to be a "representative" equilibrium, which is not necessarily the case.

The calibration procedure itself is straightforward. If, for example, a consumer has Cobb-Douglas preferences and his demand for a good q_i is observed to be \tilde{q}_i , his income is known, \tilde{y} , and the prevailing prices are \tilde{p}_i , then his demand function is given by

$$\tilde{q}_i = \alpha_i \frac{\tilde{y}}{\tilde{p}_i}.$$

The above equation is an equation with one unknown – the share parameter α_i . Rearranging yields

$$\alpha_i = \frac{\tilde{q}_i \tilde{p}_i}{\tilde{y}}$$

with the share parameter α_i expressed as a percentage of total consumption. The values of this parameter are called point estimates as opposed to estimates. This reinforces the fact that only a single year's data or a single observation represented as an average over a number of years is used.

3.6 Counterfactual & Welfare Measurement

Once the functional forms have been calibrated (to the benchmark data), the stage is set for policy analysis since the calibrated parameters can now be used to compute alternative, i.e. counterfactual equilibria. New counterfactual equilibrium states can be compared with the initial equilibrium state and conclusions can be drawn in terms of policy impacts. A question that is often raised when an old and a new equilibrium state are compared, is whether a policy has increased the social welfare of the economy under consideration.

Standard microeconomic theory proposes two methods to numerically measure welfare gains and losses: Compensating variation and equivalent variation. Since CGE models are rooted in microeconomic theory, these are the measures that are usually drawn upon. Taking the new equilibrium incomes and prices as its point of departure, compensating variation asks how much income would have to be added or taken away from a consumer in order to reestablish his initial utility level. Equivalent variation, on the other hand, departs from the initial equilibrium incomes and prices and asks how much income would be needed to achieve new equilibrium utilities. Since both compensating variation as well as equivalent variation are measured in monetary units, the individual variations can simply be summed up across consumers to calculate the welfare improvement or loss for the entire economy.

The concepts can also be used to make potential pareto improvements in social welfare, meaning those that gain from a policy compensate those that lose by using some lump-sum redistribution scheme. However, it must be stressed that CGE models only address efficiency issues and do not consider actual redistribution.

Chalmers & Weiler (2011) have recently addressed the issue of social welfare in the context of an urban CGE model. In order to understand policy induced gains and losses of two distinct groups, namely original residents versus new arrivals as well as welfare impacts to the city as a whole, they incorporated a social welfare function into the Fort Collins CGE model outlined by Schwarm & Cutler (2003). Such a function allows evaluations of welfare evolutions among a community's citizens. It can also be used to express a variety of perspectives on inequality by choosing different aversions to social inequality with the particular choice then representing a city's willingness to tolerate unequal incomes in its pursuit of economic development.

4 Summary and Outlook

Growing environmental concerns as well as rising income and wealth inequalities inflict increasing pressure on local policy makers, who are already faced with a wide spectrum of urban planning problems. Consequently, the demand for assessment tools capable of encompassing policy induced economic impacts is likely to grow. CGE models are ideally suited to address questions of resource allocation and income distribution in market economies. They have become a widely accepted policy assessment tool over the past two decades but are currently still primarily a field for specialists and seldom used in urban settings. This can be ascribed to shortcomings on the part of education and research institutions since tuition tends to focus on theoretical rather than applied models and CGE-oriented research tends to focus on national and regional rather than urban issue.

This paper showed that a lot can be gained from urban CGE modeling. By laying out the theoretical structure of a simple model of the urban housing market first and then discussing how urban issues can be dealt with in the framework of a CGE approach, the paper emphasized the significance and necessity of both the theoretical as well as the applied approach. Urban economic models such as the one laid out in the present paper are in general highly stylized portrayals of the urban economy. Their value is to be seen in their ability to identify and display relevant variables and relationships. Greater realism can and has been added to models of this kind in order to increase their predictive performance on a more detailed level of urban morphology. This, however, comes at the expense of analytical tractability.

CGE models complement analytical models by allowing for more detail and complexity while retaining the theoretical structure. It was shown that the construction of a SAM framework allows the incorporation of a large variety of actors that can be further disaggregated into specific groups differentiated from one another by various characteristics and that nesting structures can be employed to fully model the interrelatedness of economic sectors. Thus, a large variety of policy impacts can be assessed. Of course, from an urban perspective, this presupposes spatially disaggregated data, which is not always available. Although there are methods to deal with this

problem, it appears noteworthy to point out that semi- and non-survey methods are less accurate than survey-based ones. This has implications for model results bearing in mind that the calibration method assumes the economy under consideration to be in equilibrium and that this equilibrium is representative.

Static (computable) general equilibrium models, which have been the focus of this paper, do not consider a temporal dimension. This is why growth paths cannot be studied with these models and the question of whether the economy resumes to an equilibrium state after a change in parameters has occurred remains largely unaddressed. The integration of dynamic aspects has been the focus of a growing new literature in economics in general as well as in urban economics. The developed (theoretical) models are considerably more complex than their static counterparts. They can generally be differentiated by the way expectations are modeled. While myopic agents expect future prices to remain the same as current prices, perfectly foresighted agents correctly anticipate future prices when making decisions. Clearly, the first approach is flawed because agents do not adjust to a change in parameters. It is, however, far easier to handle mathematically. A good overview of the theoretical contributions attempting to introduce temporal aspects into the framework of the monocentric city model can be found in Brueckner (2000).

References

- Alonso, W. (1964). *Location and Land Use*. Mass.: Harvard University Press.
- Armington, P. S. (1969). Theory of Demand for Products Distinguished by Places of Production. *IMF Staff Papers*, 16, pp. 159-178.
- Brueckner, J. K. (1987). The Structure of Urban Equilibria: A Unified Treatment of the Muth-Mills Model. In E. S. Mills (Ed.), *Handbook of Regional and Urban Economics* (Vol. II, pp. 821-845). Amsterdam: Elsevier Science Publishers B.V.
- Brueckner, J. K. (2000). Urban Growth Models with Durable Housing. In J.-M. Huriot, & J.-F. Thisse (Eds.), *Economics of Cities* (pp. 263-289). Cambridge, New York u.a.: Cambridge University Press.
- Chalmers, K., & Weiler, S. (2011). Sorting Winners and Losers: Using CGE Models to Assess Income Distribution Effects of Economic Development Choices. *Regional Science Policy & Practice*, 3 (1), pp. 1-15.
- Mills, E. S. (1967). An Aggregative Model of Ressource Allocation in a Metropolitan Area. *American Economic Review* (57), pp. 197-210.
- Minguez, R., Osterhaven, J., & Escobedo, F. (2009). Cell-corrected RAS Method (CRAS) for Updating or Regionalizing an Input-Output Matrix. *Journal of Regional Science*, 49 (2), pp. 329-348.
- Morrison, W. I., & Smith, P. (1974). Nonsurvey Input-Output Techniques at the Small Area Level: An Evaluation. *Journal of Regional Science*, 14 (1), pp. 1-14.
- Muth, R. F. (1969). *Cities and Housing*. Chicago: The University of Chicago Press.
- OECD. (2003). *Glossary of Statistical Terms*. Retrieved August 14, 2011, from OECD: <http://stats.oecd.org/glossary/detail.asp?ID=2476>
- Peng, A. (2009). Introducing CGE Models to the Classroom Using EXCEL. *Working Paper No. 013*. Toronto, Canada: Ryerson University, Department of Economics.
- Schwarm, W., & Cutler, H. (2003). Building Small City and Town SAMs and CGE Models. *RURDS*, 15 (2), pp. 132-147.
- Shoven, J. B., & Whalley, J. (1984). Applied General Equilibrium Models of Taxation and International Trade: An Introduction and Survey. *Journal of Economic Literature*, 22 (3), pp. 1007-1051.
- Turnbull, G. K. (1988). The Effects of Local Taxes and Public Services on Residential Development Patterns. *Journal of Regional Science*, 28 (4), pp. 542-562.
- Von Thünen, J. H. (1826). *Der isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie* (5. ed.). Aalen: Scientia.



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