SELECTING PARAMETER VALUES FOR GENERAL EQUILIBRIUM MODEL SIMULATIONS*

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INTRODUCTION

Computable general equilibrium (CGE) Models are often used to simulate the impacts of various tax policy changes or reforms. Differences in results across models are attributable to both differences in model structures and differences in parameter choices. This paper focuses on the latter issue, examining the ranges of estimated values for numerous key parameters. Special emphasis is placed on the intertemporal and intratemporal elasticities of substitution and adjustment cost parameters.

CONSUMPTION PARAMETERS

The Elasticity of Intertemporal Substitutability

One of the most important and most contentious CGE model parameters is the elasticity of intertemporal substitutability (EIS). The EIS determines the responsiveness of consumption (and often leisure) over time to changes in the relative price of present and future consumption, or analogously, how responsive consumer savings is to a change in the net rate of return to capital. In general, there are two opposing views about the value of the EIS. On the one hand, empirical investigations of the EIS using aggregate consumption data, such as Hall (1988), generally indicate that the EIS is very small, perhaps near zero. On the other hand, many proponents of real business cycle models argue that the EIS is closer to one. For example, Weil (1989) shows that low values of the EIS lead to unrealistically high risk-free rates of return, which is referred to as the "risk-free rate puzzle."[1] Lucas (1990) uses a similar argument to show that an EIS below 0.5 is implausible. Jones et al. (2000) argue that an EIS between 0.9 and 1.25 is needed to generate reasonable risk-free rates of return. Prescott (1986) selects a value of 1.0 based on several empirical estimates, contending that they provide strong evidence for such a conclusion. More recent evidence emphasizes that the EIS seems to vary across individuals considerably depending on their stock market participation; Guvenen (2006) argues that this evidence may reconcile the conflicting views on the value of the EIS.

Empirical studies using aggregate consumption data typically find that the EIS is less than one. Weber (1970) initially estimated the EIS to lie between 0.13 and 0.41, but later concluded that the EIS is between 0.56 and 0.75 (Weber, 1975).[2] Subsequent studies derive their estimates from models of optimal household portfolio behavior under uncertainty. Ghez and Becker (1975) assume nonadditive separability and obtain an estimate of 0.28. Grossman and Shiller (1981) report that the EIS is between 0.07 to 0.35, Mankiw (1981) and Mankiw et al. (1985) estimate values of 0.25 and 0.37, respectively, while Summers (1982) reports an EIS of approximately 0.33. Mankiw, Rotemberg, and Summers (1985) specify a model that expands upon the literature by experimenting with a variety of aggregation methods and testing a broad range of instruments. They present a utility function that is nonadditively separable so that the marginal utility of consumption depends on the level of leisure. Their measures for the EIS range between 0.09 and 0.51. However, their model yields rejections of their estimates and the authors suggest the model is misspecified.

Using postwar quarterly data, Hall (1988) reports estimates ranging between 0.10 and 0.34 and concludes that the EIS is not likely to be above 0.1 and may be zero. However, Ogaki and Reinhart (1998) suggest that Hall's decision to ignore substitution between durable and nondurable goods and his failure to account for the effects of changes in the real interest rate on the user cost of durable goods, may lead to a downward bias in those estimates. After correcting for these factors, their estimates of the EIS range between 0.9 and 1.0. Similarly, Basu and Kimball (2002) reject additive separability on the grounds that it is simply a mathematical convenience rather than a realistic assumption. Their estimate of the EIS is approximately 0.5 using a

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King-Plosser-Rebelo utility function that allows for additive nonseparability in consumption and leisure. Ziliak and Kneisner (2005) report an EIS of 0.96 and attribute their relatively high estimate to endogeneity issues related to their estimation of the Euler equation. Gruber (2006) asserts that the traditional Euler equation approach is limited due to time-series movements related to the consumption or savings decision. His use of simulated tax rates yields an estimate of the EIS of 2.0.

Another branch of empirical research attempts to estimate the EIS across consumers that are differentiated by their saving or consumption patterns. Campbell and Mankiw (1989) argue that aggregate consumption is best viewed as generated by two groups of consumers – one group that chooses a consumption path consistent with the permanent income hypothesis and another group that consumes current income or saves following a rule-of-thumb (e.g., saving a fixed percentage of income). They show that the EIS for permanent income consumers is close to zero.[3] Mankiw and Zeldes (1991) investigate the role of limited stock market participation and conclude that one must control for stockholder status when estimating consumption patterns. Vissing-Jorgensen (2002) uses the U.S. Consumer Expenditure Survey to estimate structural equations for asset holders and nonasset holders. Her estimates for the EIS range between 0.3 and 0.4 for the former and 0.8 to 1.0 for the latter. She also shows that her EIS estimates are larger within both groups for households with larger asset holdings.

Guvenen (2006) argues that the opposing views about the size of the EIS can be reconciled by accounting for empirical evidence that shows the differences in stock market participation across households and the positive correlation between wealth and the EIS. He introduces these two features into a standard real business-cycle model and shows that movements in economic aggregates such as investment and output, which are more volatile, are determined primarily by the high EIS of stockholders; and that movement in aggregate consumption is determined primarily by the low EIS of non-stockholders since consumption is more evenly distributed than wealth. He concludes that when consumption of each group is aggregated from individual-level data, the "average of elasticity" figure approaches zero, yet when the group is split into non-stockholders and stockholders, the elasticities approach zero and one, respectively.

The range of estimates for the EIS used in CGE models is quite small, primarily because the chosen value must generate a steady-state capital stock that is consistent with the data. Auerbach and Kotlifoff (1987), Fullerton and Rogers (1993), Jorgenson and Yun (2001), Altig et al. (2001), and Diamond and Zodrow (2007, 2008) all assume a value of the EIS between 0.25 and 0.50, depending partly on the interaction of the EIS with the choice of the pure rate of time preference parameter (discussed below). Gravelle (2007) argues that even these low values can produce relatively large savings responses that are inconsistent with empirical estimates of saving behavior. Given the evidence supporting the heterogeneity of the EIS across households, an important path for future research in CGE modeling is examining the macroeconomic and distributional effects of allowing for differences in the EIS across heterogeneous households.

The Elasticity of Intratemporal Substitutability

The intratemporal elasticity of substitution parameter reflects the willingness of an individual to substitute between consumption and leisure within a given period, and is thus related to an individual's single-period labor supply elasticity. In addition, it is related to the intertemporal wage elasticity, the rate at which consumers substitute labor between periods in response to wage changes across periods. The intratemporal elasticity of substitution determines the Frisch labor supply elasticity, which is the elasticity of labor supply holding the marginal utility of income constant. In CGE models, the intratemporal elasticity and the percentage of the endowment devoted to leisure are key parameters that determine the compensated and uncompensated wage elasticities. As a result, the larger is the share of the initial time endowment devoted to leisure, the larger the percentage change in labor supply associated with an increase in the wage rate for a given value of the intratemporal elasticity of substitution (Gravelle, 2007).[4]

Auerbach and Kotlikoff (1987), Altig et al. (2001), and Gravelle (2007) note that there is relatively little direct empirical evidence on the value of the intratemporal elasticity of substitution parameter. Ghez and Becker (1975) report an aggregate value of 0.83, while Auerbach et al. (1983) and MaCurdy (1981) show that a wide range of combinations of the intratemporal elasticity of substitution and the pure rate of time preference parameter generates reasonable wage elasticities. Ziliak and Kneisner (2005) note that the macroeconomics literature often ignores the possibility that households may alter their labor supply choices over time in the face of unanticipated wage changes, so that individuals can accumulate precautionary savings instead of forgoing current consumption, a point highlighted by Gravelle (2007). They also conclude that it is essential to incorporate joint progressive taxation of labor and nonlabor incomes. Taking these factors into account, their estimates of the intratemporal elasticity of substitution range from 0.09 to 0.23, significantly lower than the prior econometric literature.[5]

Auerbach and Kotlikoff (1987) report estimates of the intratemporal elasticity of substitution that range from 0.30 to 1.50, yielding own-period compensated and uncompensated wage elasticities ranging from 0.1 to 0.5. Auerbach and Kotlikoff select a base case value of 0.80, approximately equal to the estimate of Ghez and Becker (1975). Altig et al. (2001) select the same parameter choice in their base case, but also use a value of 0.4 in some simulations. Fullerton and Rogers (1993) set the intratemporal substitution parameter equal to 0.5, arguing that higher values yield unrealistically high-wage elasticities of labor supply. Diamond and Zodrow (2007, 2008) use a value of 0.6 in their benchmark simulation.

The Pure Rate of Time Preference Parameter

The selection of the individual discount rate or pure rate of time preference parameter in a CGE model is typically made to generate reasonable consumption and labor supply profiles, taking into account its interaction with the elasticity of intertemporal substitution. High values for the discount rate result in low savings. There appears to be little empirical evidence on the appropriate choice for this parameter. Ziliak and Kneisner (1999) use the empirical Euler equation to derive the marginal utility of net wealth and to estimate the discount rate. Based on two specifications, they estimate values of 0.001 and 0.013. Jorgensen and Yun (2001) estimate a higher value of 0.02.

Auerbach and Kotlikoff (1987) select a value of 0.015 for their base case, while Fullerton and Rogers (1993) use a smaller value of 0.005. The selection by Fullerton and Rogers (1993) is motivated by the need for their simulation to generate a realistic capital stock, in conjunction with their assumptions of 0.5 for the intertemporal elasticity of substitution and a net rate of return of 0.04. Their approach is followed by Altig et al. (2001) and Diamond and Zodrow (2007, 2008), who set the pure rate of time preference parameter equal to 0.004.

Corporate vs. Noncorporate Elasticity of Substitution

The corporate vs. noncorporate elasticity of substitution reflects consumer willingness to substitute goods produced in the corporate sector for similar goods produced in the noncorporate sector in response to changes in their relative prices. Gravelle and Kotlikoff (1989) use values of 0.5 and 2.0 in their analysis of the effects of the corporate income tax. Eichenbaum and Hansen (1990) use 5.0. Fullerton and Rogers (1993) use a value of 5.0 in their central case, primarily to generate reasonable estimates of the sizes of both sectors within an industry despite differing tax treatments, and also use 20.0 in some simulations.

Income Elasticity for Housing Demand

The income elasticity of housing demand measures consumer sensitivity toward the consumption of housing goods with respect to a change in household income. There are two common approaches for deriving this estimate. The first (and most common) is to estimate a housing demand equation in which tenure choice and housing demand are jointly determined. Examples include Hoyt and Rosenthal (1990), who estimate an elasticity of 0.18, and Goodman (1988), who estimates a range of 0.2 to 0.3. Macrae and Turner (1981) reach similar results, while Henderson and Ioannides (1986) report a range of 0.35 to 0.45. These studies typically rely upon a log-linear specification. Rosen (1979) assumes housing demand is determined by the interaction of consumer income and market prices, resulting in a non-homothetic specification, an extension of the traditional approach that yields an estimate of approximately 1.0. Albouy (2007) notes that Goodman and Kawai (1986) cannot reject a value of 1.0 and calculate a similar value of 0.95. Hansen et al. (1998) compute the income elasticity of demand for housing from the estimated parameters of Lorenz and housing concentration curves, yielding estimates that range from 0.12 to 0.54.[6] An advantage of the Lorenz curve approach is that it permits elasticities to vary in a nonstructured way with income. Hansen et al. (1998) note that their approach considers income only and does not account for other variables that may affect housing.

The variation in the literature is largely due to differences in functional specification and the aggregation of the income variable. The two approaches, both traditional and Lorenz-based, yield estimates that imply consumers are relatively income insensitive with respect to their demand for housing.

Price Elasticity of Housing Demand

Rosen (1979) estimates a value of 0.97 which is comparable to estimates reported in earlier cross-section studies. Hoyt and Rosenthal (1990) report a similar price elasticity of 0.94 as do Henderson and Ioannides (1986), who derive a value of 0.8. In general, empirical estimates of the price elasticity of housing demand fall into a fairly narrow range between 0.8 and 1.0.

PRODUCTION PARAMETERS

The Elasticity of Substitution in Production

The elasticity of substitution in production describes the rate in which firms can substitute capital for labor in response to changes in relative factor prices. Most of the general equilibrium literature assumes all industries are perfectly competitive and firms exhibit constant returns to scale. Berndt and Christensen (1973) estimate a value of 1.02, concluding that a Cobb-Douglas (C-D) production specification closely approximates the underlying production process. Jorgensen (1984), Jorgensen et al. (1992), McKibbin et al. (1999), and Balesteri et al. (2002) agree that empirical evidence supports the use of C-D. Auerbach and Kotlikoff (1987) assume the production process to be C-D. Fullerton and Rogers (1993) calibrate their model using values ranging from 0.676 to 0.960 depending on the industry. Jorgensen and Yun (2001) use elasticities of substitution between labor and noncorporate capital of 0.7, and labor and corporate capital of 0.5. Altig et al. (2001) begin their simulation using a C-D production function for their base case, but in later simulations consider a constant-elasticity-of-substitution (CES) functional form with a value of 0.8. Chirinko et al. (2002) suggests a lower value of 0.4 and provides evidence that a C-D production function grossly overstates the sensitivity of capital and labor substitutability. Gravelle (2007) notes that setting the elasticity of substitution in production to unity, is inconsistent with recent empirical estimates. She argues that short-run elasticities are inherently smaller than long-run elasticities, due to technological restrictions in the short-run, causing one to question the C-D functional form in a short-run setting.

Capital Intensity Parameter

The capital intensity parameter describes the ratio of capital to labor for all factor prices. The parameter is typically approximated by using the most recent macroeconomic data on capital markets. The parameter is usually estimated by determining the ratio of the historical share of capital to national income. Auerbach and Kotlikoff (1987) and Altig et al. (2001) select a value of 0.25. They note that for a C-D production function, factor shares remain fixed and the capital intensity parameter reduces to the capital share in income.

Marginal Adjustment Cost Parameter

Adjustment costs reflect the costs associated with adjusting the capital stock in response to a change in the cost of capital; they are usually assumed to be convex (typically quadratic), and cause firms to smooth their investment responses to changes in tax policies. The marginal adjustment cost parameter is interpreted as the additional adjustment cost expenditure required for a one dollar increase in the capital stock. For example, Summers (1981) estimates an adjustment cost parameter of approximately 0.22, implying that it costs an additional twenty cents to increase the capital stock by one dollar. Shapiro (1986) estimates a dynamic model (an Euler equation estimation) for labor and capital that does not rely on the q-based quadratic approach of Summers (1981). He points out that estimating the Euler equations allows for a more flexible functional form and permits an uncertain discount rate. Hassett and Newmark (2008) point out that many of these estimates seem implausibly high. Shapiro's (1986) estimates indicate that adjustment costs are approximately zero. Cummins et al. (1994) dispute the estimates of Shapiro (1986) and suggest that an extra dollar of investment costs between 0.05 and 0.12 dollars.[7] Hall (2004) expands upon Shapiro (1986) by using less aggregated data and the identifying assumption that military spending and the timing of oil price shocks are strongly exogenous variables.[8] He finds very little evidence of adjustments costs.[9]

The base case model of Auerbach and Kotlikoff (1987) ignores adjustment costs altogether, consistent with the empirical work by Shapiro (1986) and Hall (2004). In some simulations, Auerbach and Kotlikoff (1987), and Altig et al. (2001) use a marginal adjustment cost parameter of 10, consistent with the higher estimates of Cummins et al. (1994).[10] In their examination of the transitional effects of enacting a consumption tax reform, Diamond and Zodrow (2007) also perform simulations based on two marginal adjustment cost parameters, zero in a base case and 10 in other simulations. However, the work by Hall (2004) appears to reconcile many of the differences in earlier higher estimates of adjustment costs, and suggests that adjustment costs are much lower than previously estimated.

Notes

1. The Euler consumption equation can be rearranged so that $R=P+(1/EIS)*\log(C_{t+1}/C_t)$, where R is the risk-free rate of return on investment, P is the preference parameter, and C is consumption. Lucas (1990) shows that any value above 0.5 would generate an unrealistically high R.
2. Auerbach and Kotlikoff (1987) note that earlier estimates, such as Weber (1970, 1975), focus strictly on consumption. Weber (1975) expands his earlier work by considering separately the consumer choices between durable and nondurable goods.
3. Note that Campbell and Mankiw (1989) only report an EIS estimate for permanent income consumers because by definition rule-of-thumb consumers do not make choices using an intertemporal framework.
4. Gravelle (2007) also notes that the utility functions typically used in CGE models, which are characterized by constant elasticities of substitution and unitary income elasticities, are quite restrictive.
5. The Ziliak and Kneisner (2005, 2008) econometric approach uses a continuously differentiable smooth budget constraint, rather than the usual piecewise-linear budget set, resulting in less measurement error.
6. Lorenz curves indicate the cumulative proportion of income received by cumulative proportions of households when the households are ranked by income. Similarly, a concentration function for housing provides the cumulative proportion of housing consumed by cumulative proportions of households when the households are ordered by income. See Hansen, Formby, and Smith (1998).
7. Their analysis differs by their use of changes in tax policy as a source for identifying determinants in tax policy decisions.
8. When the instruments are uncorrelated with the errors of the Euler equations and uncorrelated with the innovation in the ratio of the share parameters, Hall (2004) refers to them as "strongly exogenous."
9. Hall (2004) uses no lagged endogenous variables in his estimates in order to avoid the bias found in other studies. In particular, unlike Shapiro (1986), he does not rely upon pure timing considerations in his choice of instruments.
10. Prior estimates, such as those of Summers (1981), Abel and Blanchard (1986), and Poterba and Summers (1983), are based on regressions of investment on calculated values of q. However, each of the aforementioned authors had substantial reservations about their respective estimates, suggesting one should use caution when implementing these values, as noted by Auerbach and Kotlikoff (1987).

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