CAPITAL MOBILITY IN CGE MODELS: A SURVEY

by

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1. Introduction

Computable General Equilibrium (CGE) models are an important tool of economic analysis. They are widely used in many different areas of economic study including trade, development, and even economic history. This paper is not about CGE models in general. It focuses on only one particular aspect of CGE modeling, namely specification of capital mobility.

Treatment of capital is an important issue in building CGE models. The problem begins even at the level of data. While input-output tables generally provide data on labor, they do not contain data on capital stock. Sometimes estimates of aggregate capital stock can be derived following perpetual inventory or some other similar method. However, this cannot provide sectoral capital stocks, because national income accounts data do not generally provide sectoral investment figures. Given this situation, CGE modelers often have to construct capital data themselves using depreciation and other relevant data.

But serious modeling problems arise even after capital data have been constructed. These problems revolve around the following three questions. First, whether or not capital is to be treated as mobile across sectors. Second, whether or not capital is to be treated as mobile across borders of the economy. Third, whether or not capital accumulation is to be thought as part of an inter-temporal optimization process. The issue of mobility of capital is also intimately connected with the issue of mobility of savings.

In actual applications, different CGE modelers provide different answers to these questions. However, they do not always spell out the alternatives that are available and do not explore implications of one choice over another. Works like that of Devarajan and Offerdal (1989), where the authors actually experiment with alternative ways of modeling capital mobility, is rather rare. In recent years, excellent monographs on CGE modeling have been published. These include Mercenier and Srinivasan (1994) and Shoven and Whalley (1992). These are important additions to earlier volumes on CGE modeling such as De Melo, Dervis, and Robinson (1982) and Scarf and Shoven (1984). However, a discussion exclusively focussed on various capital mobility issues is still lacking.
This paper is an attempt to fill that void. It provides a fairly comprehensive catalogue of situations that may arise with regard to capital mobility and discusses different ways in which these situations can be and have been dealt with in CGE literature. Finding this discussion in one place will help researchers to clearly see the choices that they have, the ways to implement these choices, and possible implications of the choices made. This will also help the general reader to compare and evaluate results obtained from different CGE models.

Overall, the discussion of the paper shows that the concrete nature of the capital mobility issue differs greatly depending on the context being considered. It is difficult and perhaps not even desirable to recommend one particular approach for all possible situations. Which particular approach should be adopted depends largely on the purpose with which the model has been built and is being used. Nevertheless, it is possible to make some general points, and these have been summarized in the concluding section.

The paper begins by emphasizing the distinction between mobility of savings and of capital (section-2). Different ways of viewing the actual process of capital movement are also spelled out here. Section-3 identifies different theoretical contexts in which issues of capital mobility may be considered. The paper then moves on to discuss how in the CGE literature issues of capital mobility in these different contexts have been dealt with so far. In section-4, we consider within-border capital mobility issues. The approach to capital accumulation based on inter-temporal optimization is also discussed here. The issues of across-border mobility of capital are discussed in section-5. In section-6 we conclude.

This paper does not aim to be a complete survey of CGE literature related to capital mobility. The purpose is rather to cover the issues with as much brevity as possible. Accordingly, it does not cite and discuss all the papers that deal with capital mobility. However, this does not mean that these works are any less important. Also, we limit ourselves here to only such CGE models that rely generally on assumptions of perfect competition. Many researchers such as Harris (1984), Rodrik (1988), and others have emphasized the importance of imperfect competition and scale economies in the context of CGE models. We hope that better understanding of capital mobility issues in the context of simpler, perfect competitive model will also help better comprehension of these issues in more complicated models involving imperfect competition.
2. Capital Mobility: Some Conceptual Issues

2.1 Distinction between Mobility of Capital and Mobility of Savings

At the outset, it is necessary to emphasize the distinction between ‘mobility of capital’ and ‘mobility of savings.’ By ‘capital’ one often refers to capital goods and structures that are already in place and are participating in production in the current period. In this sense, capital would imply current capital. ‘Savings,’ on the other hand refers to future capital. Savings allow purchase of investment goods in this period, and these investment goods start functioning as capital only in the next period. In the current period, the total capital stock available to the economy cannot be augmented through savings. Thus, the distinction between ‘capital’ and ‘savings’ is inherently linked with the distinction of periods. In fact, this distinction stands or falls depending on whether or not periods are distinguished. In the current period, savings only have (investment) demand-effect, and no supply-effect. Its supply effect is postponed until the next period, by which time savings are transformed into new capital stock.

This distinction may seem obvious, and it may seem even banal to emphasize it. However, as we shall see, considerable confusion may arise if we are not careful about this difference. The confusion in this regard has been aggravated by sloppy use of terminology. It is common to talk about mobility of ‘capital,’ when in fact what is being referred to is mobility of ‘savings.’ For practical purposes, there may be grounds for doing this. However, sometimes it is misleading to use these terms interchangeably, because the two represent very different processes. In order to avoid this ambiguity, in our discussion below, we shall adopt the following terminology.

a) Mobility of current capital denotes mobility of capital that is already in place and is participating or can participate in production during the current period.

b) Mobility of savings denotes mobility of resources that become capital in the next period through purchase and installation of investment goods during this period.

c) Mobility of capital is an encompassing expression, which will be used only when the statement holds for both current capital and savings.
2.2 Two Ways of Viewing the Actual Process of Capital Mobility: The Issue of Implicit Duration of the Time Period

In CGE modeling, an important issue is whether mobility is to be allowed only for savings or for current capital too. In part, this depends on the way the actual process of movement of capital across sectors or borders is viewed. This, in turn, is related to the implicit duration of the time period considered.

Mobility of capital also figures prominently in trade theory where it is routine to assume capital to be mobile across countries. However, the actual process of movement of current capital is not always spelled out. In fact, there are two alternative ways of viewing this process. One is to think that machines and structures already in place and/or in use are physically transferred from one country to another (or, from one sector to another). For short, we can term this view of capital mobility as ‘movement through trade in used capital.’ This way of viewing current capital mobility, however, runs into two problems. The first concerns movement across economies. Actual trade statistics do not show much evidence of movement of old machines, equipment, and structures. The second concerns movement across sectors. The above way of viewing capital mobility belittles technological differences of capital goods across sectors. When these differences are taken into account, it is difficult to think how capital from one sector can be effortlessly used in another sector or economy. Current physical capital, from this point of view, is hardened clay and not putty, and hence, it cannot readily augment capital stock of another sector.

In light of the above, the following alternative view of capital mobility may seem to be more realistic. In this view, current capital does not change its location. Instead, it gets run down through depreciation. Funds coming from depreciation finance capital formation in the sector or economy of destination. In this way, current capital becomes fungible (putty) and can take whatever concrete form is necessary in the new economy or sector. For short, we can refer to this view of capital mobility as the ‘movement through depreciation.’

Hence, it is clear that there is a link between which view of the actual process of capital movement is adopted and the implicit duration of the time period considered in a CGE model. If

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1 As we shall see, this has been noted by other researchers too.
2 The standard texts of trade theory do not generally flesh out the actual process of capital movements. However, one place to look for a good discussion on this topic is Kenne (1994, pp.110-2, 168-70). He also spells out the changes in the trade flows that are associated with the capital ‘movement through depreciation.’
‘movement through trade in used capital’-view holds true, then current capital can move right away, within a period of *short duration*. In contrast, ‘movement through depreciation’ requires a period of *long duration*, equaling almost to the effective lifetime of the capital goods concerned. Thus, if mobility of current capital is to be allowed, and ‘movement through depreciation’ is thought to be correct, then the implicit duration of the period has to be *long*. On the other hand, if the implicit duration of the period is *short*, then either mobility of current capital has to be ruled out, or ‘movement through trade in used capital goods’-view of capital mobility has to be upheld.

3. Different Contexts of Capital Mobility

There are at least two dimensions for classification of contexts in which to consider the capital mobility issue. The *first* of these relates to the boundary within which the processes of capital mobility are to occur. In other words, the question here is, what is the spatial unit? From this point of view, we have the following two possible situations:

a) Within-Border and  
b) Across-Border.

The term ‘border’ here does not necessarily refer to international political border between sovereign countries. Instead, it just refers to the boundary of whatever spatial unit is under consideration for modeling.

The *second* dimension concerns the time horizon within which capital mobility is considered. This becomes important in the context of a multi-period model, which allows capital movement to be seen from across-period point of view. This coincides with the issues of capital accumulation, i.e., of determination of savings and their allocation by sector of destination. From this perspective, we can again have the following two possible situations:

a) Within-Period, and  
b) Across-Period.

Thus a variety of contexts may arise from different combinations of the situations listed above. The issues of capital mobility differ depending on the particular context considered, and so
do the set of possible treatments. In the next two sections, we identify these contexts and discuss the specific nature of capital mobility issues in these contexts.

4. Within-Border Mobility

We begin by considering issues of within-border capital mobility. As is perhaps clear, this can be considered in two variants, namely (i) within-border and within-period, and (ii) within-border and between-period.

4.1 Within-Border and Within-Period

Mobility of Capital

In the context of a within-border and within-period situation, the main issue is whether or not current capital is mobile across sectors. It is quite common to have CGE models with current capital sectorally fixed for the period. The sectoral rates of return on capital will then have to be different, and they can not be forced to conform to any particular predetermined pattern. In other words, sectoral rates then serve as endogenous variables that equilibrate demand for sectoral capital stocks to their predetermined supply. The solution of the model under this arrangement yields a vector of sectoral equilibrium rates of return on capital.3

The other option is to make current capital mobile across sectors. In this version, the average rate of return adjusts to make aggregate demand of capital equal to its aggregate supply. The solution of the model, in this case, produces economy-wide single equilibrium rate of return on capital. However, in this setting it is further possible to have sectoral rates of return conform to some predetermined pattern. The equilibrium allocation of capital across sectors then adjusts to that pattern of rates.

Devarajan and Offerdal (1989) provides a good discussion of these two different ways of modeling current capital mobility in a within-period and within-border context. They draw attention to the fact that sectorally fixed capital version represents the situation in the short run, while the mobile version represents the situation in the long run. In terms of our discussion in

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3 In actual implementation, the average rental rate is generally kept as an endogenous variable, and one of the sectoral proportionality factors is fixed.
section-2.2, the short run situation corresponds to ‘trade in used capital’ view of current capital mobility, and the long run situation corresponds to ‘movement through depreciation’-view of current capital mobility.\(^4\)

**Mobility/Allocation of Saving**

Within a period, the issue of mobility or allocation of saving is of limited consequence. As we have noted earlier, savings do not have capital augmenting role or supply-effect within the period. It has *demand effect* because volume and allocation of savings by sector of destination influence the aggregate amount and the sectoral composition of *investment demand*.

However, different ways of modeling current capital mobility have some bearing on the problem of savings allocation by sector of destination. As we have just noted, absence of sectoral mobility results in a solution vector of sectoral rates return on capital. These rates can then serve as a guide for savings allocation. Higher proportions of saving may be earmarked for sectors with higher rates of return on current capital. On the other hand, when sectoral mobility of capital is allowed, we obtain a single, economy-wide rate of return, and this cannot provide much guidance to ‘optimal’ allocation of savings among sectors. The allocation decision then has to be based on some other considerations.

**4.2 Within-Border and Across-Period**

When we are in a within-period situation, multi-period (or infinite) horizon considerations do not enter into savings decision making process. The decisions then have to be myopic, and only the current period information or considerations can be used to arrive at those decisions. The utility function used to allocate income between consumption and saving is based entirely on current period variables.\(^5\)

The presence of multiple periods in the model changes the situation in an important way. Now, savings of the current period can play a capital-augmenting role in the next period. In

\(^4\) Devarajan and Offerdal (1989) also check how far the results of policy simulation differ depending on these two alternative ways of modeling capital mobility. Their results based on the CGE model for Cameroon, however, do not show that the results vary that much.

\(^5\) However, note that saving is inherently a variable of dynamics. Even in the within-period context, decisions regarding saving cannot but involve considerations that span at least two periods.
addition to affecting demand of the current period, it now affects the supply of the next period. Thus, volume of saving now has a more fundamental effect on the model results. This also makes consideration of future periods an important factor in deciding about current period’s savings.

Also, in the context of a multi-period CGE model, the distinction between mobility of savings and of current capital loses some of its potency. Even if current capital is not allowed to be mobile in the current period, mobility of savings can compensate for that by changing capital stocks of the next period. Thus, the decision whether or not to allow within-period mobility of current capital has less influence when the entire time horizon (i.e., all periods together) is considered.

The issue of ‘closure’ also figures importantly in this connection. In the neoclassical closure, all savings find outlet in investment. In other words, volume of investment is determined by volume of savings. An alternative is to adopt the Keynesian closure, whereby investment assumes primacy and determines savings. In a compromise, however, both savings and investment functions can have role.6

While both the saving function (of neoclassical closure) and the investment function (of Keynesian closure) can be considered in the context of a single period model, they both can have more sophisticated treatment in a multi-period setting. However, despite this commonality, the two approaches differ with regard to their implication for allocation of saving to destination sectors. The savings function approach can better capture the sources of savings, but it cannot, by itself, provide a sufficient basis for allocation of savings by sector of destination. On the other hand, the investment function approach, to the extent that it proceeds from determination of investment requirements by sectors, provides not only the total volume of investment required, but also its sectoral distribution.7 However, the investment functions cannot point out the sources of savings needed to carry out those investments.

In a multi-period CGE model, the process of capital accumulation generally can be modeled in two ways. The *first* of these involves inter-temporal optimization, while the second does not involve such optimization. For brevity, we refer to the first as the *optimal approach*, and

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6 For more detailed discussion of the closure issue see the pioneering discussion by Sen (1963).
7 This is not surprising because sectoral allocation of saving is in fact allocation of investment. Therefore the it is only natural that the investment function approach displays strength in this respect just as the saving function approach is more capable in dealing with differences in the sources of saving.
the second, as *sequential approach*. In either case, the modeling involves incorporation into the model of a between-period part that updates the stock variables from one period to the next.

**Capital Accumulation with Inter-temporal Optimization**

The concrete way to implement an inter-temporally optimal process of capital accumulation depends on the type of closure rules adopted. Goulder and Summers (1989), for example, sketch an approach that combines both saving and investment functions. The investment function in their setup is derived from firms’ inter-temporal maximization of their value. Investment is also assumed to involve adjustment costs given by an adjustment cost function $\phi(I/K)$, where $I/K$ is investment to capital ratio. Assuming that the production function is of constant returns to scale and the adjustment cost function is homogeneous of degree zero in $I/K$, the optimal investment demand becomes a function of $Q$ (unadjusted Tobin’s $q$) as shown below:

$$
\frac{I}{K} = h(Q).
$$

Furthermore, if the adjustment cost function has a suitable quadratic form, then the investment demand function simplifies to

$$
\frac{I}{K} = \gamma + \frac{1}{\beta} Q,
$$

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8 In Goulder and Summers (1989) set up, $Q$ is given by

$$
Q = \left[ \frac{V - B}{p K} - 1 + ITC + b + \omega Z \right] \left[ \frac{p K}{(1 - \tau) p} \right],
$$

where, $V$ is the present value of the firm, $B$ is the present value of depreciation allowances on existing capital, $p K$ is the replacement price of capital goods, $ITC$ is investment tax credit rate, $b$ is the debt-capital ratio (that is assumed to be kept constant), $Z$ is the present value of depreciation allowances on a dollar of new investment, $\tau$ is the corporate tax rate, and $\omega$ is a combination of various tax rates given as $\omega = a (1 - \theta)/(1 - c) - a + 1$, where $a$ is the fraction of after-tax profit paid out as dividend, $\theta$ is the marginal income tax rate, and $c$ is the capital gains tax rate.

9 Goulder and Summers (1989) assume the adjustment cost function to be as follows:

$$
\phi(I/K) = \frac{\beta / 2(I/K - \gamma)^2}{I/K},
$$
where $\gamma$ and $\beta$ are parameters of the adjustment cost function. This shows that rate of investment increases with $Q$, and for any given $Q$, higher adjustment costs (i.e., lower $\gamma$ and higher $\beta$) imply a slower rate of investment. Thus, we find that not only current investment affects future path of the variables, future path of the variables affects the current period’s investment. This is mediated through $Q$, which incorporate expectations about the future.

Firms can finance part of the desired investment from their retained earnings. For the remaining they have to turn to consumers’ savings. The savings side is modeled on the basis of a representative consumer who maximizes his/her inter-temporal utility function. Under suitable assumptions, the solution to the optimization problem yields the following consumption rule:

\[(3) \quad \bar{p}_t C_t = m \cdot TW_t,\]

where $C_t$ is consumption, $\bar{p}$ is the price index for consumption, $TW_t$ is the total wealth made up human and non-human wealth, and $m$ is the fraction of total wealth that is consumed and depends on parameters of the model, future prices, and interest rates. The consumption decision also determines savings. Matching of household saving with external saving requirement of the firms is one of the most important equilibrium conditions of this system.

The implementation of this approach is simplified by the assumption of perfect foresight, which reduces the problem of optimization with an infinite horizon to an iterative process of single period optimization subject to assumed values of trajectories for the stock variables. Despite this reduction of the problem to a single period solution method, the approach here is inherently based on optimization over long horizon. This is, however, not true of the sequential approach that we consider next.

*Capital Accumulation without Inter-temporal Optimization*

In the sequential approach, savings decisions of a particular period are not derived from an optimization process that takes into consideration the consequences of these decisions for the entire time path. Instead, these decisions are made either arbitrarily or by following some ad hoc rules. Thus, in this approach, consecutive within-period solutions are just *sequenced* together without any overarching optimization process that covers all periods.
The *optimal* and *sequential* approaches to capital accumulation also differ with respect to the manner of allocation of savings/investment by sector of destination. As we have noted above, if investment functions of the optimal approach are sector specific, then these also solve the problem of savings allocation. The sequential approach, on the other hand, does not generally have formal sector-specific investment functions. Hence, allocation of investment in this case has to be determined separately. The issue whether within-period mobility of current capital is allowed or not becomes relevant once again in this context.\(^\text{10}\) If such mobility is not allowed, then the current period equilibrium sectoral rates of return can serve as a basis for savings allocation of the next period. However, as we have noted earlier, when such mobility is allowed, the model solves for only one uniform rate applicable for all the sectors, and the investment allocation has to be determined on the basis of some exogenous criterion.

The discussion therefore shows that if one is constructing a multi-period CGE model, and the periods are of relatively short duration, it may be of less consequence if current capital is kept sectorally fixed within a period. Mobility of saving will compensate to a great extent for immobility of current capital. However, if it is single-period model then it is difficult to conceive current capital as mobile unless the implicit duration of the period is long. If, on the contrary, the implicit duration is short, then sectorally fixed capital may make more sense.

So far, we have been considering capital mobility issues in *within-border* context. Next we consider issues related to capital mobility *across-border*.

### 5. Across-Border Mobility

Across-border mobility can again be considered in either within-period or across-period contexts.

#### 5.1 Within-Period and Across-Border Mobility

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\(^{10}\) Note that the issue whether or not to allow within-period mobility of existing capital can also arise in the context of the optimal approach to capital accumulation. Generally, in this approach, within-period mobility is allowed. However, if the investment functions are sector specific, then it is technically possible to keep capital fixed sectorally within-period, and thus to have different rates of return on capital across sectors.
With regard to across-border mobility within-period, several approaches can be adopted.
One is illustrated by the Canadian regional model, which has been constructed by Whalley and his associates.\footnote{See for example, Whalley and Trela (1986), Jones and Whalley (1988, 1989).} This is a one period model, which emphasizes mobility of labor and capital across both sectors and regions.\footnote{The main focus in the paper is on modeling mobility of labor. In comparison, the treatment of mobility of capital is rather simple.} Note that in the context of this model, ‘border’ can have two interpretations. One is that of the boundaries of the provinces/regions. The other is the international boundary. With respect to regions and sectors, this model assumes perfect mobility. Not only can savings go to any region or sector, even current capital is considered to be perfectly mobile across sectors and regions. Hence, one single rate of return prevails in all sectors and regions and this is the rate that brings total demand for capital in line with total supply available. With respect to international mobility, two variants are possible. In one (basic) variant, current capital is assumed to be perfectly mobile internationally too. In the second variant, international mobility is not allowed.

If perfect international capital mobility is allowed then we have a combined market for capital, and there is one equilibrium equation describing the clearing of this combined market. This equation can be written as follows:

\[
\sum_{n=1}^{N,\text{ROW}} \sum_{j=1}^{J} K^n_j (r) = \sum_{n=1}^{N,\text{ROW}} \bar{K}^n,
\]

where \(N\) is the total number of regions, and \(J\) is the total number of sectors. \(\text{ROW}\) stands for ‘Rest of the World.’ \(K^n_j\) is the demand for capital of sector \(j\) in region \(n\), \(r\) is the common rate of return on capital, and \(\bar{K}^n\) is the given stock of current capital in region \(n\). In this treatment, \(\text{ROW}\) appears as just another of the regions. The hallmark of this way of modeling capital mobility is the assumption that the total supply of capital (for the economy being modeled and for rest of the world) is \textit{a-priori} known. The approach is to proceed from a known total stock of capital, \(\bar{K}\),
and arrive at an equilibrium rate of return, $r$.\textsuperscript{13} This approach therefore involves some modeling of the \textit{ROW} economy, yielding, among other things, the \textit{ROW} sectoral demands for capital.\textsuperscript{14}

However, in many situations this kind of information on capital stock may not be available. In these cases the above approach is not feasible.\textsuperscript{15} An alternative approach to modeling of across-border capital mobility may be suitable for such situations. An example of such an alternative approach can be seen in Goulder, Shoven and Whalley (1983) (henceforth GSW). This is an extension of the CGE model for the US that appeared earlier in Fullerton, Shoven and Whalley (1981) and Fullerton, King, Shoven and Whalley (1982). In GSW, the authors open up the economy and incorporate across-border trade flows and capital flows.

GSW distinguish between ‘capital as service’ and ‘capital as goods.’ This distinction is another way of dealing with the conceptual issues of capital mobility that we discussed in section-2. They propose two alternative formulations of capital mobility. One assumes the existence of an international rental market of ‘capital services.’ This would correspond with movement of current capital ‘through trade in used capital.’

In the second formulation, capital flows do not occur in the form of renting, rather it takes the form of outright purchase and sale of capital goods. In this case, the return is not obtained in the form of rental, or immediate compensation for the period, but in the form of claim on future earnings. Such outright purchases of capital goods are made by use of current period’s savings. By implication, these capital goods will not have supply effect in the current period. So this is in effect a situation of mobility of \textit{savings} and not of current capital.

In either case, the mobility is not assumed to be perfect. Rather, there is a degree to which current capital services and savings respond to the differentials in rental rate and rate of returns. This degree of responsiveness is determined by the elasticity values. Accordingly, modeling of

\textsuperscript{13} Note that this may be appropriate for a situation where the country modeled is large vis-a-vis the rest of the world.

\textsuperscript{14} If international mobility of capital is not allowed, and mobility is restricted to across regions, then we have two distinct capital markets to clear, one for the country (or economy) that is being modeled and the other for the rest of the world, \textit{ROW}. However, with international capital mobility disallowed, the necessity of modeling the \textit{ROW} capital market becomes somewhat moot. In this variant, there will again be one equilibrium rate of return across regions within the economy, namely $r_C$. However, with the \textit{ROW} capital market essentially separate from the country’s capital market, there is no reason why the equilibrium rate of return for \textit{ROW}, namely $r_{ROW}$ cannot be different from $r_C$. 

capital mobility now relies more on the knowledge of elasticity parameters and less on knowledge of total capital stock. For example, mobility of current capital (capital as service) can be specified as:

\[
\Delta K_{ROW} = K_{ROW} \left( \hat{r}_C / \hat{r}_{ROW} \right)^{\varepsilon_K},
\]

where

- \( K_{ROW} \) = capital service endowment of the ROW,
- \( \Delta K_{ROW} \) = capital service rented by ROW to the country modeled (i.e., C),
- \( \varepsilon_K \) = elasticity,
- \( \hat{r}_C \) = rental rate of capital in country C (i.e., domestic),
- \( \hat{r}_{ROW} \) = rental rate of capital in ROW.

Apparently this also requires knowledge of ‘capital service endowment of the ROW.’ However, if the domestic country is small compared with the ROW, then \( \hat{r}_{ROW} \) may be known. In that case, based on the knowledge of \( \varepsilon_K \) and the baseline values of \( \Delta K_{ROW}, \hat{r}_C, \) and \( \hat{r}_{ROW}, \) it is possible to get \( K_{ROW} \) as part of the calibration process.

Note that equation (5) describes the inflow of ‘capital services’ from ROW to the country C, and it has been formulated with \( K_{ROW} \) as the base. A negative value of \( \Delta K_{ROW} \) in this equation will imply outflow of current capital from country C to the ROW. However, this may be viewed as a structural equation describing the inflow only. The outflow may be described by another structural equation whose variables and parameters may differ from those of equation (5). The net flow will then be the resultant of flows in these two opposite directions. It is also possible to combine the two equations and have a single reduced form equation giving this net flow. However, clearly such an equation will be more involved in variables and parameters.

An illustration of the two-equation approach can be seen in the following model of mobility of ‘capital as goods’ (i.e., savings mobility).\(^{16}\) It assumes the total domestic savings to be known and then considers the question how much of these savings is used domestically (\( S_C \)) and

\(^{15}\) The regional model for USA presented by Morgan, Mutti and Patridge (1989) considers capital mobility across regions, but in the context of a closed economy, so that the issues of across border mobility do not arise there.

\(^{16}\) This is based on Goulder, Shoven, and Whalley (1983).
how much flows to the ROW ($S_{ROW}$). This is governed by an allocation parameter $\beta$. Thus, $S_C = \beta S$, and $S_{ROW} = (1 - \beta)S$, where $S$ is total savings available. The distribution parameter $\beta$ depends on the relation between $r_{ROW}$ and $r_C$, the rate of return to capital prevailing in ROW and in country $C$, respectively. It is clear to see that $\beta = 1$ if $r_C \geq r_{ROW}$. On the other hand, if $r_C \leq r_{ROW}$, $\beta$ is assumed to be given by

$$\beta = \exp[-Z_1(r_{ROW} - r_C)]$$

Clearly, $\beta$ is a transformation of the elasticity parameter. Again, the issue may be viewed from ROW side too and can be modeled analogously. For that we may use a second equation specifying the response of ROW savings to the rate of return differential.\(^{17}\) This second equation will apparently require knowledge of total ROW savings. However, as we mentioned earlier, if plausible estimates of the elasticity parameters are available then the baseline value of total ROW savings can be determined as part of the calibration process.

Thus, in these approaches, the requirement of knowledge of ROW total current capital and savings is avoided by using elasticity parameters that determine the degree of responsiveness of across border flows to differentials in rental rates or in rates of return. Broadly the approach here is to proceed from rates of return and arrive at the equilibrium value of the current capital or saving via the elasticities. Hence, this is an approach that is more suitable if the country modeled is small. However, it entails knowledge of the elasticity values.

The discussion therefore shows that in considering across-border mobility, an important issue is whether mobility is perfect or imperfect. If it is a situation of perfect mobility, then

\(^{17}\) The ROW savings behavior may be modeled as follows. (This is similar to that in GSW.) Let $S_C^{ROW}$ denote ROW saving flowing into country $C$. Then clearly,

$$S_C^{ROW} = 0 \quad \text{if} \quad r_C^{ROW} \leq r_{ROW}^{ROW},$$

$$S_C^{ROW} = Z_2(r_C^{ROW} - r_{ROW}^{ROW})^2 \quad \text{if} \quad r_C^{ROW} \geq r_{ROW}^{ROW},$$
specifications require knowledge of both domestic and ROW total stock of capital. On the other hand, a situation of imperfect mobility can be dealt with estimated elasticity values, and this may obviate the necessity of information on ROW total capital stock. The choice in this regard may also be influenced by whether or not the country modeled is large and small relative to the ROW.

5.2 Across-Border and Across-Period Mobility

Across-border capital mobility can be viewed from a multi-period viewpoint too. This is a more ambitious goal. However, there have been attempts to model across-border capital mobility in the framework of multi-period optimization. An example can be seen in Goulder and Eichengreen (1989). The approach is similar to that we saw in section(4.2) on the basis of Goulder and Summers (1989).

The derivation of the investment function proceeds in the same way as in Goulder and Summers (1989). With regard to inter-temporal optimization of the consumption/saving decision, the domestic households now have the choice of either keeping their saving inside the country or sending it abroad. In order to let this decision made optimally, Goulder and Eichengreen add another argument, \( A_s \), in the consumer's utility function. \( A_s \) is consumer’s asset holding satisfaction index and is defined as:

\[
A_s = k \left[ \alpha_0^{1-\rho} \alpha^\rho + (1-\alpha_0)^{1-\rho} (1-\alpha)^\rho \right]^{1/\rho},
\]

where, \( \alpha_0 \) and \( 1-\alpha_0 \) gives the initial distribution of the savings between domestic and foreign (ROW) assets, and \( \alpha \) and \( 1-\alpha \) is the distribution which would be optimal at time \( s \). The corollary of this is that households now also derive some of their income from their asset holdings abroad, so that their (non-human) wealth accumulation now reflects that. The consumers maximize their inter-temporal utility function subject to the wealth accumulation function, and this gives the trajectory of consumption and \( \alpha \).

where, \( r^{ROW}_C \) and \( r^{ROW}_R \) are the domestic and ROW rates expected by the ROW savers. Because the domestic savers and ROW savers are not treated identically in the domestic tax system, \( r_C \) usually differs from \( r^{ROW}_C \) and \( r^{ROW}_R \) from \( r^{ROW}_R \). This approach can be implemented without knowledge of total savings of the ROW.
An analogous process of value maximization and utility maximization is thought to be true for the ROW firms and households too. The conditions of overall equilibrium are similar to those in two-economy trade models. Assumption of perfect foresight allows conversion of the inter-temporal optimization process to an iterative process of sequential one-period optimization exercises under the assumption of particular trajectories of the variables.

It is clear is that the above is a model of mobility of savings. Current capital does not move across countries within the period. It is the capital stocks of the next period that are affected by the flow of savings across the countries in the current period. This is a departure from Goulder, Shoven and Whalley (1983) where, as we saw, across-border mobility in current capital is also considered as a variant. The problems of viewing capital mobility as ‘movement through trade in used capital goods’ are the reasons for this departure. Actually, in Bovenberg and Goulder (1991), we find explicit recognition that viewing capital mobility in the form of rental of “existing/old” physical capital is not very realistic. This leads them to think that across-border capital mobility has to be viewed mainly in the form of movement of funds (savings), which then get translated into movement of ‘new’ capital goods through external trade. This conforms more to the ‘movement through depreciation’-view of capital mobility.18 In Bovenberg and Goulder (1993) the authors provide an application of the treatment of across-border and across-period capital mobility that we describe above.19

6. Conclusions

Thus we see that there are a variety of ways in which capital mobility can be treated in a CGE model. To begin with, one needs to distinguish between mobility of current capital and mobility of savings (future capital). Next comes the task of clarifying the context in which capital mobility is being considered. These contexts depend on (a) whether mobility is considered within period or across period, and (b) whether mobility is considered within border or across border. It is therefore possible to identify four different contexts of capital mobility depending on the

18 Bovenberg and Goulder (1991) also relate their shift in view to the distinction between flow of physical capital and flow of financial.
19 This application focuses on studying the differences in the short and long run effects of ‘investment tax credit’ and ‘reduction of corporate income tax rate’ policies with and without capital mobility.
combination of situations above. The concrete nature of capital mobility issues varies depending on the context that is under consideration. Even within a particular context, different approaches are possible. The paper illustrates these approaches on the basis of examples drawn from the CGE literature. Which of these contexts and approaches best suits a particular CGE model depends on the concrete problem at hand and on the purpose of the modeling exercise.

However, some general points can be made. First, savings or future capital should generally be mobile. Second, whether or not current capital should be mobile depends on two things. First, whether it is a single- or multi-period model. Second, if it is a single period model, whether the implicit duration of the time period is long or short. If the model is a multi-period model, it becomes less important whether current capital is treated as fixed or mobile. This is because mobile savings can compensate to a great extent for immobility of current capital. In such a situation there may not be much objection to current capital being treated as fixed. However, if it is a single-period model, then much depends on the implicit duration of the time period. If the duration is long then current capital can be treated as mobile. On the other hand, if the duration is short, then it is difficult to see how current capital can be mobile.

With respect to the mobility across borders, an important question is whether this mobility is perfect or imperfect. If perfect mobility is assumed then specification of capital mobility will require knowledge of total capital stock not only of the domestic economy but also of the rest of the world. On the other hand, if mobility is imperfect, then specification can rely more on elasticities, which give degree of responsiveness of capital flows to differentials in rate of return. This is also related with the issue of the size of the domestic economy. If the domestic economy is small relative to the ROW, then it may be more difficult to know ROW total capital stock. On the other hand, if the domestic economy is large relative to ROW, error in estimating ROW capital stock may be of less consequence. However, reliable elasticity values are also not easy to get.

Finally, in a multi-period setting capital mobility may be modeled using either the (inter-temporally) optimal approach or the sequential approach. While theoretically the optimal approach is more appealing, in actual implementation, one has to invoke the assumption of perfect

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20 Single- and multi-period models are often referred to as ‘static’ and ‘dynamic’ models. However, sometimes these may be misleading. As we saw, a single-period model may have long implicit duration and allow for much mobility and dynamics. However, there is no harm in using either of the terminology as long as the implied meaning is clear.
foresight and rely on projected path of the state variables. Hence, the actual outcomes of this approach are vulnerable to these assumptions. The sequential approach, on the other hand, is computationally simpler but does have the inter-temporal optimal property.

Given this variety of contexts and approaches, it is not possible and even desirable to recommend one particular approach for all different situations. However, discussion of this paper shows that CGE modelers and readers of CGE results should be alert to all these possibilities. It is important to clearly spell out the context considered and the approach adopted. The modeler may also want to explore and show the consequences of alternative approaches. This will make the results more comprehensible and comparable.
References


Abstract

The paper considers issues of capital mobility in the context of computable general equilibrium (CGE) models. It has two parts. In the first, these issues are considered in general terms. It begins by emphasizing the distinction between mobility of savings and of capital and spells out the different ways in which the actual process of movement of capital can be conceptualized. The paper then identifies different theoretical contexts in which issues of capital mobility may be considered and discusses how these have been dealt with in earlier CGE models.