cadence|economics

EXPANDED DESCRIPTION OF CEGEM MODEL

ADDENDUM FOR THE ANTI-DUMPING COMMISSION JUNE 2018

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1. Introduction

Cadence Economics' General Equilibrium Model (CEGEM) is designed to simplify the complexity of the global economic system. The model is in the family of Walrasian computable general equilibrium models. These are descendents of the early multisectoral planning models that were built around the underlying input-output structure that reflected multisectoral consistency. As a Walrasian model, CEGEM is based on optimising behaviour of representative economic agents such as households and firms.

CEGEM, draws on the global CGE modelling framework developed by the Global Trade Analysis Project (GTAP) based at Purdue University in the United States. Their model is described in Hertel (1997), with its antecedent being the Industry Commission's Salter model (Jomini et al 1991). The GTAP model was greatly enhanced by the Australian Bureau of Agriculture and Resource Economics (ABARE) to incorporate dynamic capabilities. The MEGABARE model (ABARE 1996) and its successor, the Global Trade and Environment Model (Pant 2002), were the fruits of ABARE's efforts.

The CEGEM model is solved using software developed in-house on the freely available Python programming language, with the primary user interface implemented in Excel. Our solution software draws on Python packages including SciPy and Pandas, both widely used in the data science community.

Overview of the modelling framework

CEGEM is a large scale, dynamic, multi-region, multi-commodity computable general equilibrium model of the world economy. The model allows policy analysis in a single, robust, integrated economic framework. This model projects changes in macroeconomic aggregates such as GDP (or GSP at the State level), employment, export volumes, investment and private consumption. At the sectoral level, detailed results such as output, exports, imports and employment are also produced.

The model is based upon a set of key underlying relationships between the various *components* of the model, each which represent a different group of agents in the economy.

The components include a representative household, producers, investors and international (or linkages with the other regions in the model, including other Australian States and foreign regions). Below is a description of each component of the model and key linkages between components.

CEGEM is based on a substantial body of accepted microeconomic theory. Key assumptions underpinning the model are:

- The model contains a 'regional consumer' that receives all income from factor payments (labour, capital, land and natural resources), taxes and net foreign income from borrowing (lending).
- Income is allocated across household consumption, government consumption and savings so as to maximise a Cobb-Douglas utility function.
- Household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In the Australian regions, households can also source goods from interstate. In all cases, the choice of commodities by

source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.

- Government consumption for composite goods, and goods from different sources (domestic, imported and interstate), is determined by maximising utility via a Cobb-Douglas utility function.

- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital.

- Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a CES production function.

- Producers are cost minimisers, and in doing so choose between domestic, imported and interstate intermediate inputs via a CRESH production function.

- The supply of labour is positively influenced by movements in the real wage rate governed by an elasticity of supply. This is most often assumed to be 0.15 for central case scenarios, and 0.3 for high side scenarios, depending on the employment market conditions for the region under consideration.

- Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: global investment and rates of return in a given region compared with global rates of return.

- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.

- Prices are determined via market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other Australian regions (interstate exports).

- For internationally-traded goods (imports and exports), the Armington assumption is applied whereby the same goods produced in different countries are treated as imperfect substitutes. But in relative terms imported goods from different regions are treated as closer substitutes than domestically-produced goods and imported composites. Goods traded interstate within the Australian regions are assumed to be closer substitutes again.

- The model accounts for greenhouse gas emissions from fossil fuel combustion. Taxes can be applied to emissions, which are converted to good-specific sales taxes that impact on demand. Emission quotas can be set by region and these can be traded, at a value equal to the carbon tax avoided, where a region’s emissions fall below or exceed their quota.

Dynamics

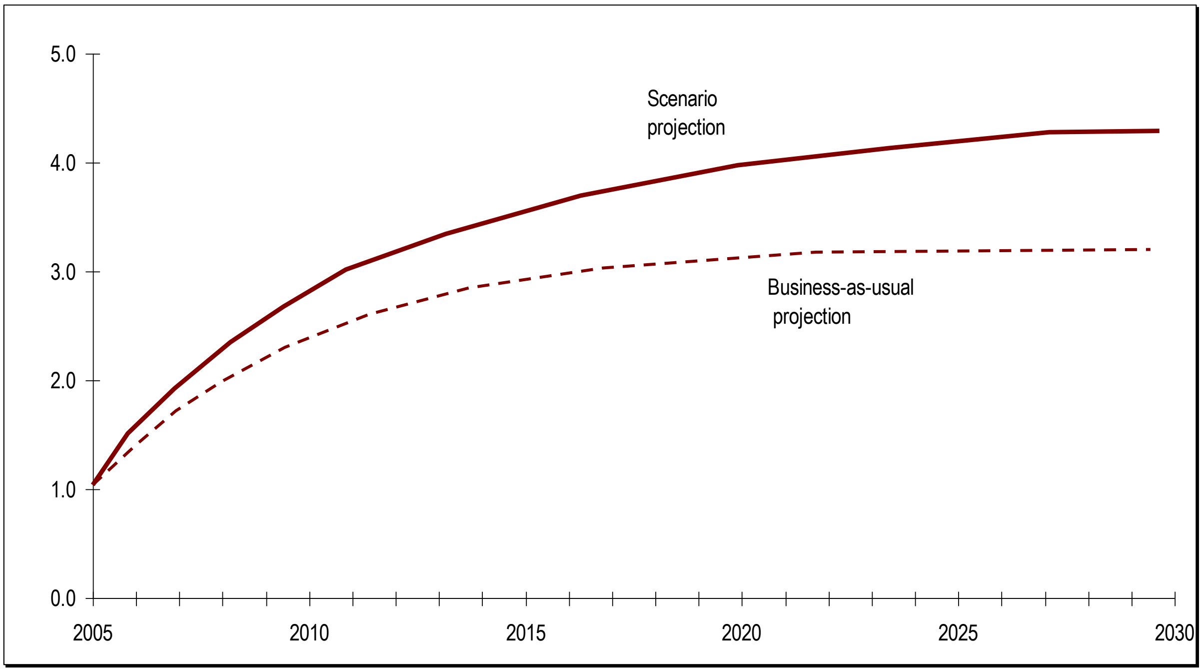
CEGEM is a recursive dynamic model that solves year-on-year over a specified timeframe. This has two main advantages. First, dynamics allows a richer specification of the model in that issues such as debt accumulation (which facilitates the ability to model international capital flows) and labour market dynamics are able to be modelled in a more sophisticated manner. Second, scenario analysis using a model such as CEGEM can be greatly enhanced by the ability to alter the baseline, or reference case, to account for key developments or uncertainties.

The model is then used to project the relationship between variables under different scenarios, or states, over a pre-defined period. This is illustrated in Figure 1, where a reference case or 'business-as-usual' scenario forms the basis of the analysis undertaken using CEGEM. The model is solved year-by-year from time 0 which reflects the base year of the model (2001) to a predetermined end year (in this case 2030).

The 'Variable' represented in the figure could be one of the hundreds or thousands represented in the model ranging from macroeconomic indicators such as real GDP to sectoral variables such as the exports of iron and steel from Australia. In the figure, the percentage changed in the variables have been converted to an index (= 1.0 in 2005) and is projected to increase by 2030.

Set against this business-as-usual scenario is, in Figure 1, a 'Scenario projection'. This scenario represents the impacts of a policy change or different assumptions about economic development that results in a new projection of the path of the variable over the simulation time period. The impacts of the policy/assumption change are reflected in the differences in the variable at time T. It is important to note that the differences between the business-as-usual and expansion scenario are tracked over the entire timeframe of the simulation.

Figure 1: Dynamic simulation using CEGEM



Detailed interdependencies

The model is underpinned by a detailed, global database. The model's database is 'benchmarked' or 'calibrated' so that initial equilibrium solution exists that replicates actual sectoral production, consumption, trade and factor usage.[1] It contains 129 regions and 57 sectors for a base year of 2007, and is the benchmark dataset for applied, global general equilibrium modelling. This database produced by the Global Trade Analysis Project (GTAP) at Purdue University is the most detailed and comprehensive database of its type in the world. Used by some 700 researchers globally, the database is a truly international, collaborative research effort that is fully documented and transparent (see McDougall 2006).

The CEGEM model is primarily based on input-output or social accounting matrices, as a means of describing how economies are linked through production, consumption, trade and investment flows. For example, the model considers:

- direct linkages between industries and countries through purchases and sales of each others goods and services; and
- indirect linkages through mechanisms such as the collective competition for available resources, such as labour, that operates in an economy-wide or global context.

The remainder of this document describes the fundamental aspects of the model.

[1] Because the model is balanced in that income equals expenditure across regions (and across the world) and that trade balances and balance of payments are in equilibrium, this ensures that Walras's law is maintained. In fact, the checking of Walras's law is integral to determining the validity of any experiment undertaken with the model.

2. Description of the model

This section outlines the structural features of the model. This section provides a description of the various aspects of the model, assisted by diagrams and mathematical exposition where appropriate.

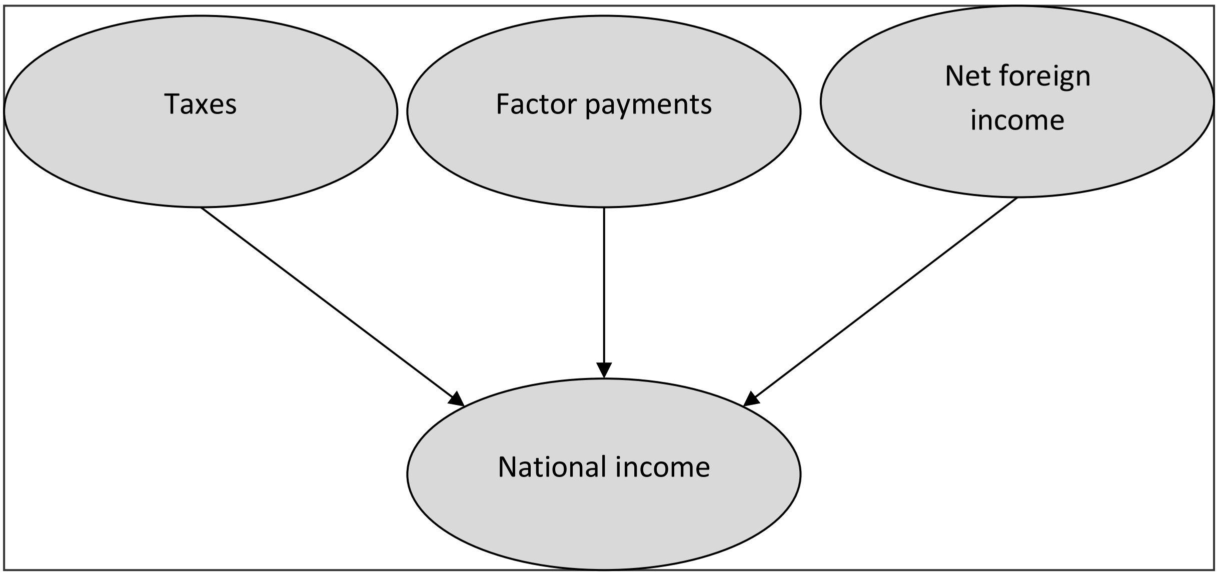
The following description covers:

- National income and expenditure
- The demand side of the model
- The supply side of the model
- Equilibrium

National income and expenditure

Each region in the model has what is called a ‘regional consumer’ that collects all income generated. This includes all taxes, factor payments and net foreign income generated by borrowing/lending abroad (Figure 2). There are four factors of production in the model: labour, capital, land and natural resource that will be discussed in more detail below. One of the flow-on effects of using the regional consumer assumption is that the choice of welfare measure in the model becomes a simple matter of gross national income.

Figure 2: Determination of national income



The main equation detailing gross national income in levels form is:

$$YFULL_r = Factor\ \ payments + Taxes + Net\ \ foreign\ \ income$$

It shows that nominal gross national product in a given region (*yfull*) is a share weighted sum of the various components shown in Figure 2. This includes primary factor payments (*ps* and *qo*), a raft of taxes from different sources (there are 12 sources of taxation revenue recognised in CEGEM) and net income from overseas (*c_FY*). Tax revenue is derived by taking the difference between transaction values at agent's prices and market prices.

The regional household distributes the income (nominal) generated over three expenditure items; private household consumption, government consumption and savings (Figure 3). All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital. Government consumptions moves in line with national income. Private consumption is, therefore, a residual.

Nominal government consumption takes the form:

$$YG_r = \delta_r.YFULL_r$$

where YG_γ is nominal government consumption, δ_γ is the ratio of government consumption to national income, and $YFULL_\gamma$ is nominal gross national product.

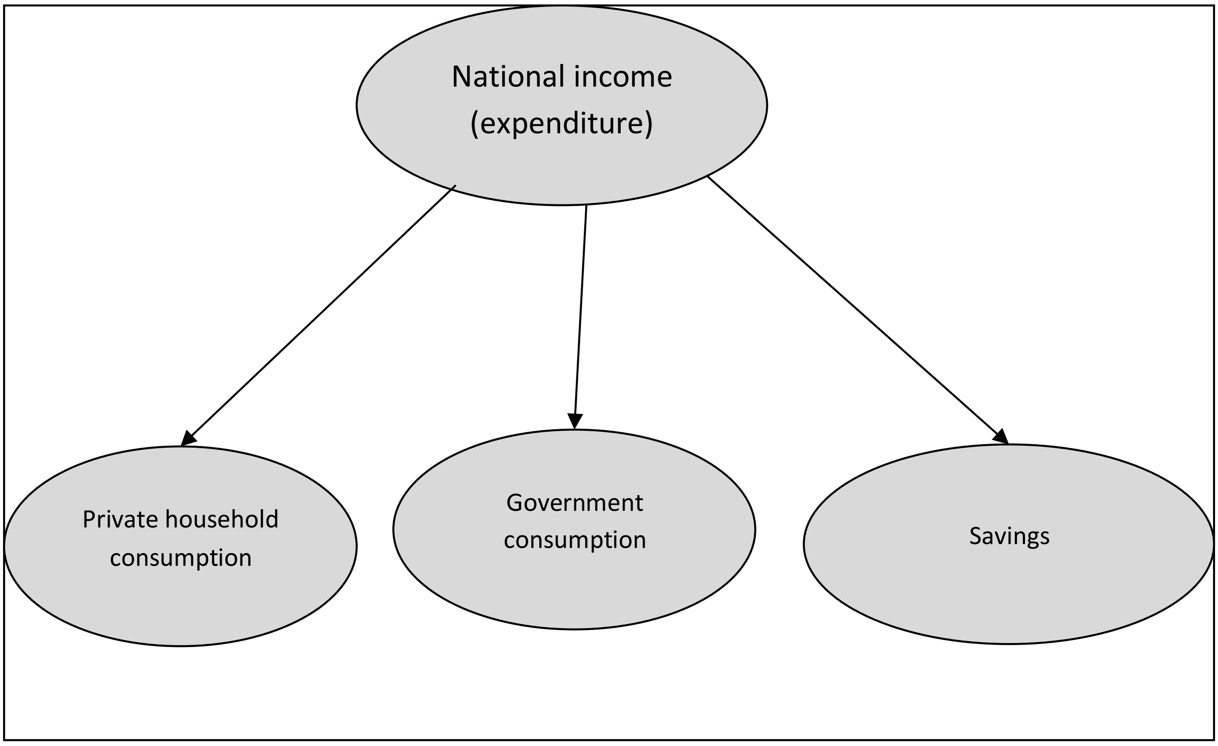
Private household expenditure is determined as the residual of $YFULL_\gamma$, YG_γ and YS_γ (nominal savings). In this case, nominal income in levels is given by:

$$YFULL_r = YP_r + YG_r + YS_r$$

When converted to percentage changes, this becomes:

$$GNP\_i_r.yfull_r = PRIVEXP_r.yp_r + GOVEXP_r.yg_r + REGSAVE_r.ys_r$$

Figure 3: National spending



Demand side of the model

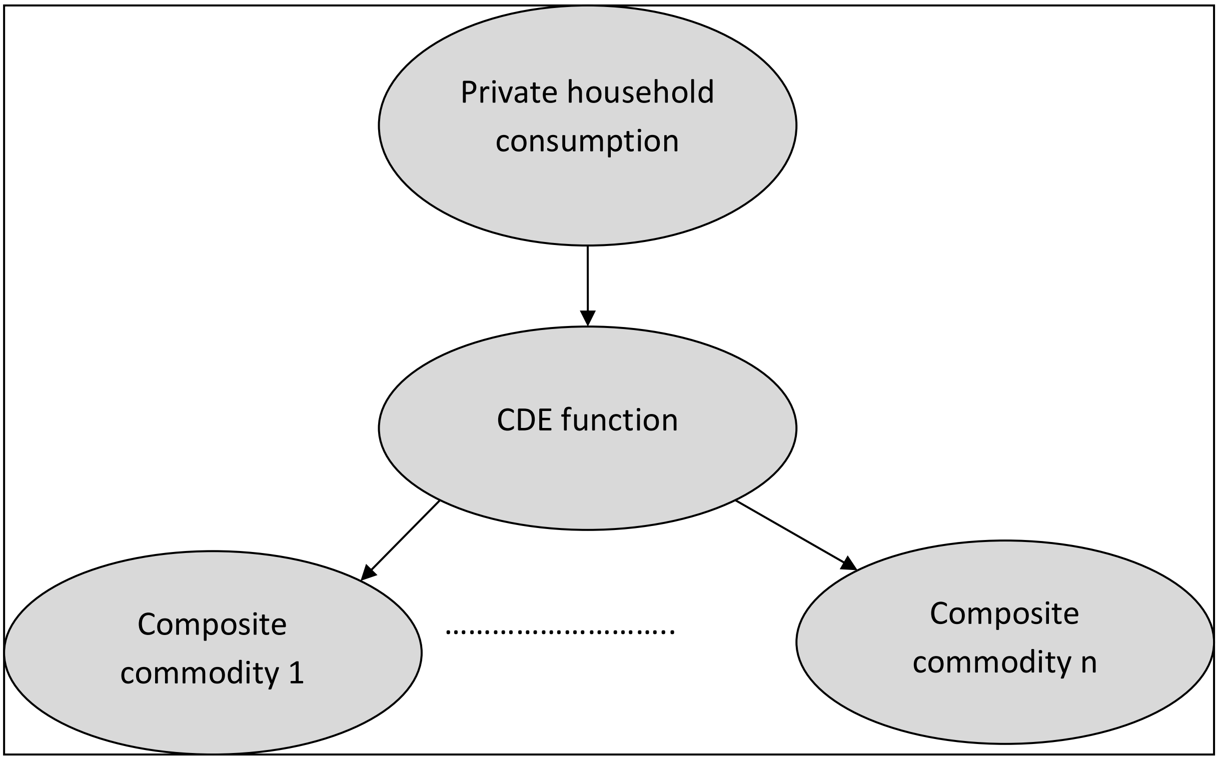
The demand side of the model is described below. General equilibrium models are sometimes referred to as 'top-down' models because of their use of nested production and consumption functions.

Private household consumption

Once aggregate private household consumption (or the budget constraint) is determined, the determination of which commodities to consume (to maximise utility) and whether to source the commodities from domestic or imported sources (to minimise costs) takes place. The first step is to determine consumption of a 'composite commodity' or the goods and services private households will consume, regardless of whether they are sources domestically or imported.

Consumers maximise utility subject to a budget constraint and given prices. The model uses the Constant Difference in Elasticity of substitution (CDE) expenditure function outlined in Hanoch (1975) and summarised in Figure 4. The CDE function is also employed in the GTAP model (Hertel et al 1991). This function implies that the difference in the Allen partial elasticities of substitution between pairs of commodities is constant regardless of the choice of pairs. In practical terms, this function has the advantage in that it allows budget shares to change as income changes. This is an important feature in a dynamic model such as CEGEM.

Figure 4: Allocation of private household consumption across composite commodities



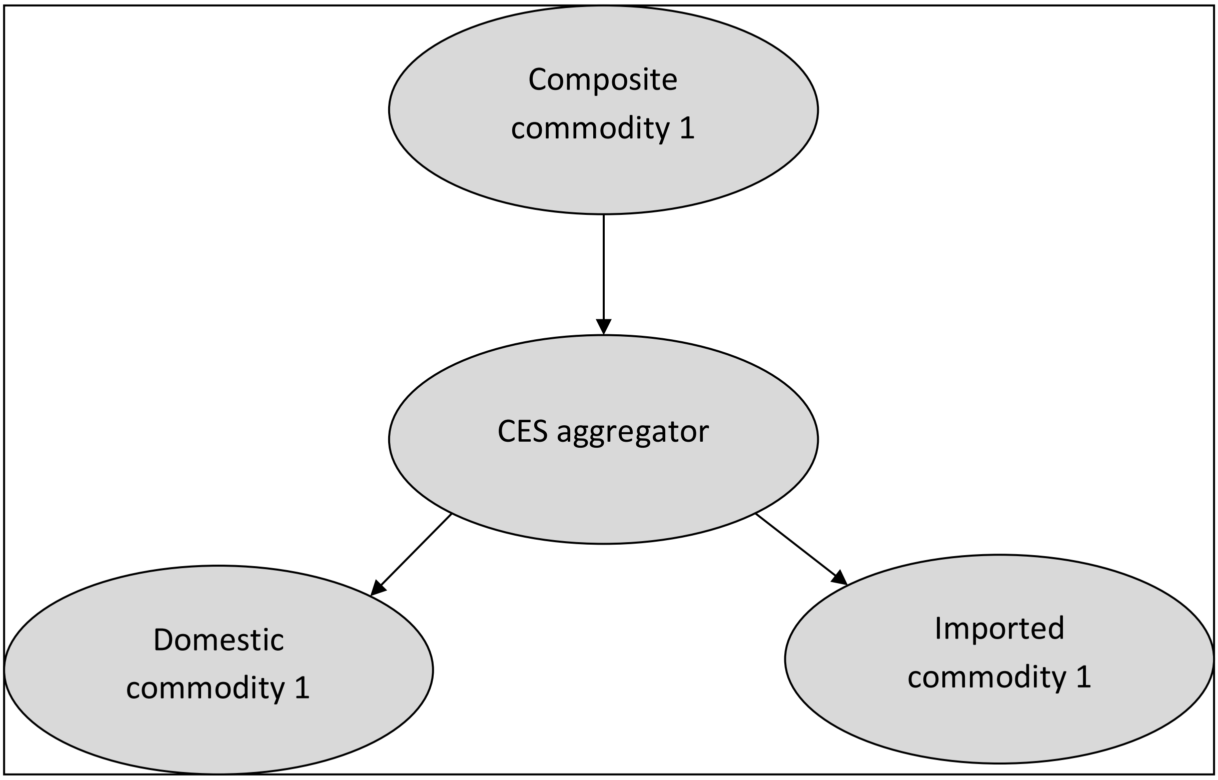
The CDE implicit expenditure function is given by:

$$\sum_{iTRAD\_COMM} B_{i,r}.UP_r^{\beta(i,r)\gamma(i,r)}.\left[\frac{PP_{i,r}}{E(PP_r,UP_r)}\right]^{\beta(i,r)} \equiv 1$$

where *E*(.) is the minimum expenditure required to maintain a given level of utility UP_r given prices PP_r. To calibrate the function involves choosing appropriate values for β (compensated own price elasticities) and γ (income elasticities of demand). The term $B_{i,r}$ relates to the budget share of commodity *i* in region *r*.

After determining the quantity of composite commodities that will be consumed, the next stage is to minimise costs by choosing between domestic and imported sources. This is done through a Constant Elasticity of Substitution (CES) aggregator function (Figure 5). This assumes that domestic and imported sources are not perfect substitutes as described by Armington (1975).

Figure 5: Allocation of private household consumption across domestic and imported sources



In the case of an applied general equilibrium model with more than one input, a CES production function (ignoring technical change) takes the form of:

$$Z = \left(\sum_i \delta_i X_i^{-\rho} \right)^{\frac{-1}{\rho}}$$

The problem is to choose inputs *X* (*i*=1,…,*n*) to minimize the cost of the above function to produce output *Z*. Following the analysis outlined in Wittwear (1999), the percentage change function enters CEGEM in the following form:

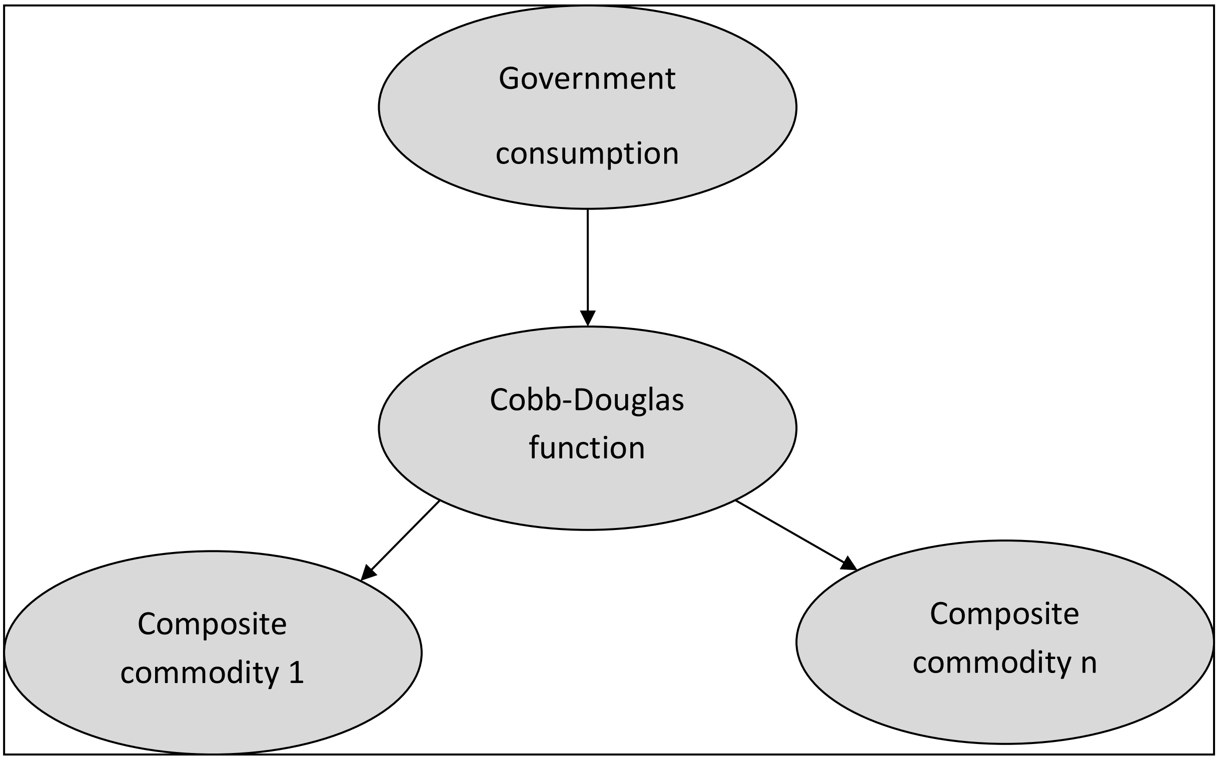
$$x_k = z - \sigma(p_k - p_{ave})$$

where x_k is the percentage change in input demand for commodity *k*, *z* is the percentage change in demand for each output, p_k is the price of the given input and p_{ave} is the average price of all inputs in the substitution bundle. The function implies that demand depends on output changes as well as changes in relative prices. The parameter σ governs the substitution between demand for x_k and its alternatives (the so-called Armington elasticity).

Government consumption

Similar to private household consumption, aggregate government is determined in two stages to maximise utility and minimise costs. The first step is to determine consumption of a 'composite commodity' or the goods and services governments will consume, regardless of whether they are sourced domestically or imported. This is done through a Cobb-Douglas function (Figure 6). The Cobb-Douglas function is equivalent to applying fixed proportions.

Figure 6: Allocation of government consumption across composite commodities



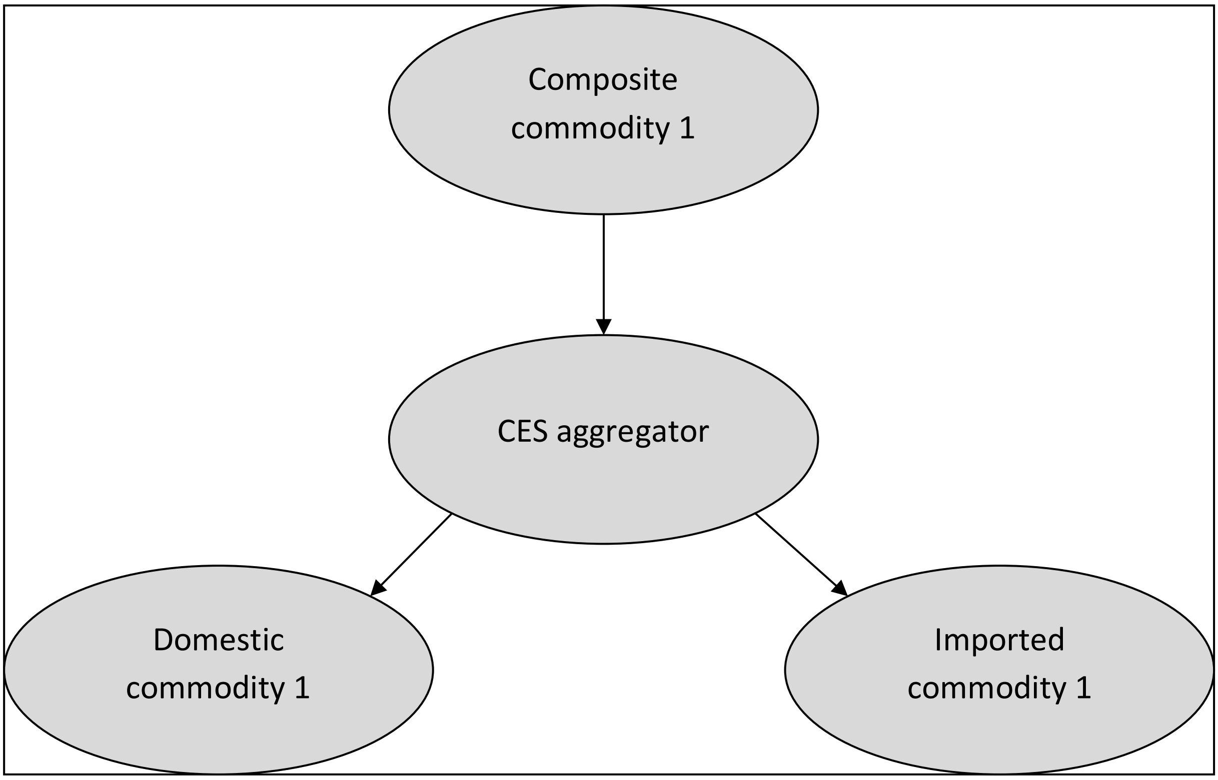
The Cobb-Douglas government utility function implies that the government purchases a fixed share of goods and services over time, or that:

$$yg_r = pg_{i,r} + qg_{i,r}$$

where $pg_{i,r}$ and $qg_{i,r}$ are the percentage changes in the price and quantity of government consumption of good *i* in region *r* respectively. This implies that the percentage change in nominal consumption of any individual commodity by government is the same as the aggregate percentage change in nominal government consumption.

After determining the quantity of composite commodities that will be consumed, the next stage is to minimise costs by choosing between domestic and imported sources. This is done through a Constant Elasticity of Substitution (CES) aggregator function (Figure 7).

Figure 7: Allocation of government consumption across domestic and imported sources



Savings

The income allocated to savings is used to purchase bonds in the global market. These bonds are used to fund investment which, in turn, becomes units of capital. Bonds are issued by a combination of domestic and foreign sources.

As savings are used to fund investment, the price of bonds is determined by the prices of investment goods in each region. This generally relates to construction and heavy machinery costs. These are the physical goods and services required to produce units of capital in the model. Overall, the global price of savings is an average of each region's price of investment goods. For each region, the price of savings will reflect the global price of savings and exchange rates.

For a given region, the price paid for a global bond is defined as

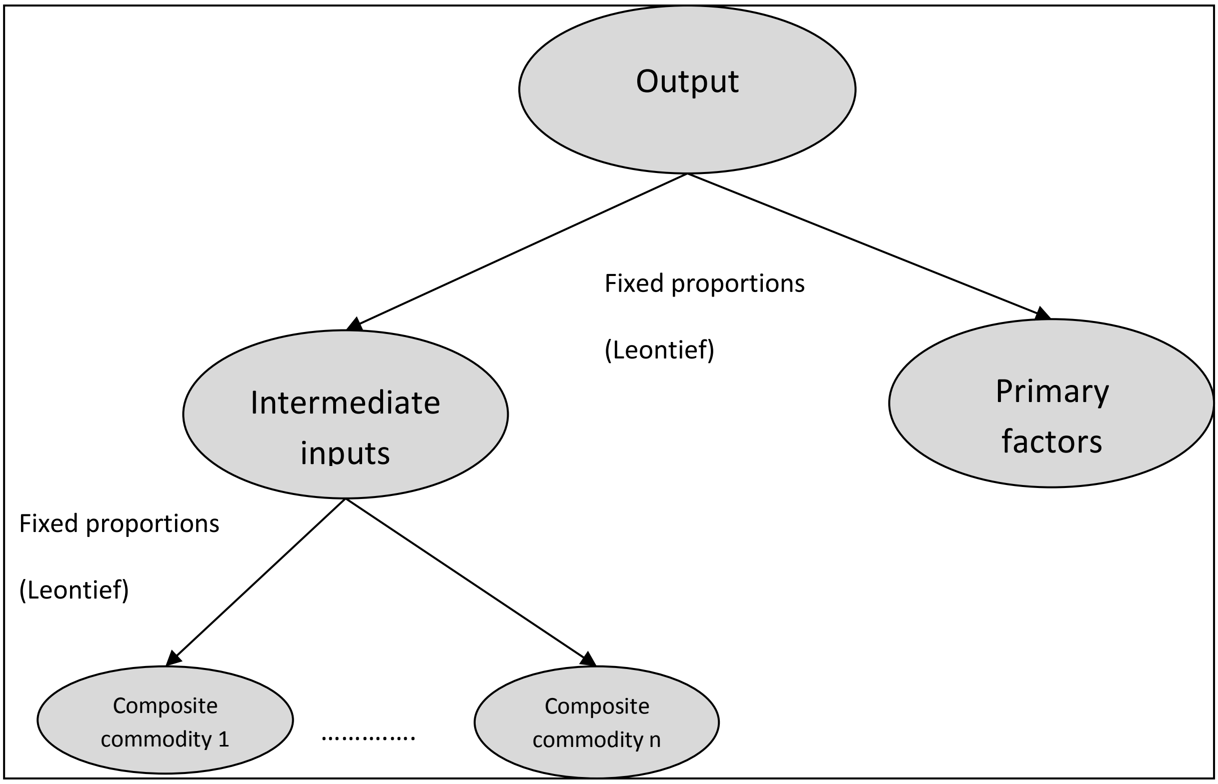
$$\frac{PSAVE_r}{\Phi_r} = PSAVE^{Global}$$

where $PSAVE^{Global}$ is the global price of savings, $PSAVE_r$ is the price of savings in region r and Φ_r is the exchange rate, defined as units of domestic currency per global currency unit.

Production

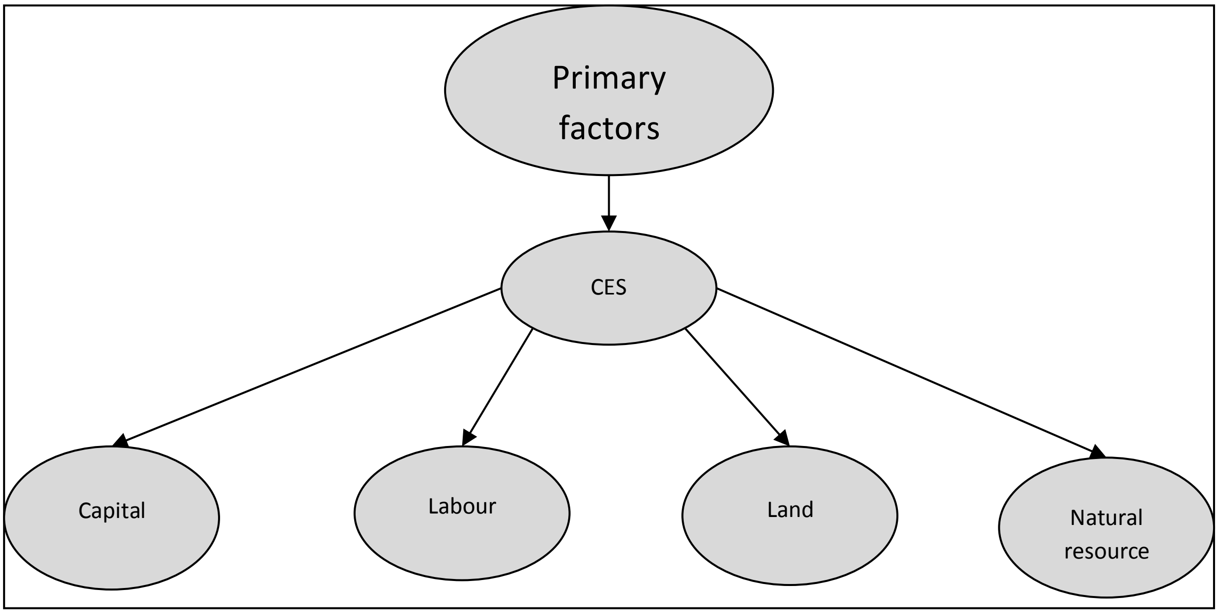
Producers in the model are price takers who operate in perfectly competitive markets. The production function represents constant returns to scale. They generate zero 'pure profits'. They produce output by combining intermediate inputs (goods and services used in production) and a composite primary factor bundle in fixed proportions (Figure 8). This is the so-called Leontief assumption. In terms of intermediate inputs, it is further assumed that composite commodities used in production are also used in fixed proportions. In a similar manner to Figure 6, producers minimise the cost of intermediate inputs by substituting between domestic and imported sources governed by a CES aggregator function under the Armington assumption (not shown in Figure 8).

Figure 8: Usage of intermediate inputs and primary factors in production



To minimise costs of production, substitution is allowed between primary factors through a CES aggregator function (Figure 9).

Figure 9: Usage of primary factors in production



Aggregate Investment

Investment takes place in a global market in CEGEM. It allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. As discussed above, savings are converted into bonds that fund investment. There is a global investor that ranks countries (rather than individual industries) based on two factors: current economic growth and rates of return in a given region compared with global rates of return.

The specification of the investment function follows that employed by Pant (2002) and is summarised in equation (1). In any particular region r at time t, real investment ($Inv_{r,t}$) equals a proxy measure of aggregate output ($Y_{r,t}$ which is set equal to real GDP in CEGEM) and the difference between the expected rate of return in region r at time t ($R^e_{r,t}$) and the global interest rate at time t (R^w_t). There are two parameters governing the function; ρ_r which is a parameter governing how quickly global investors respond to changes in rates of return and global interest rates, and β_r which is a parameter indicating the rate of return in region r.

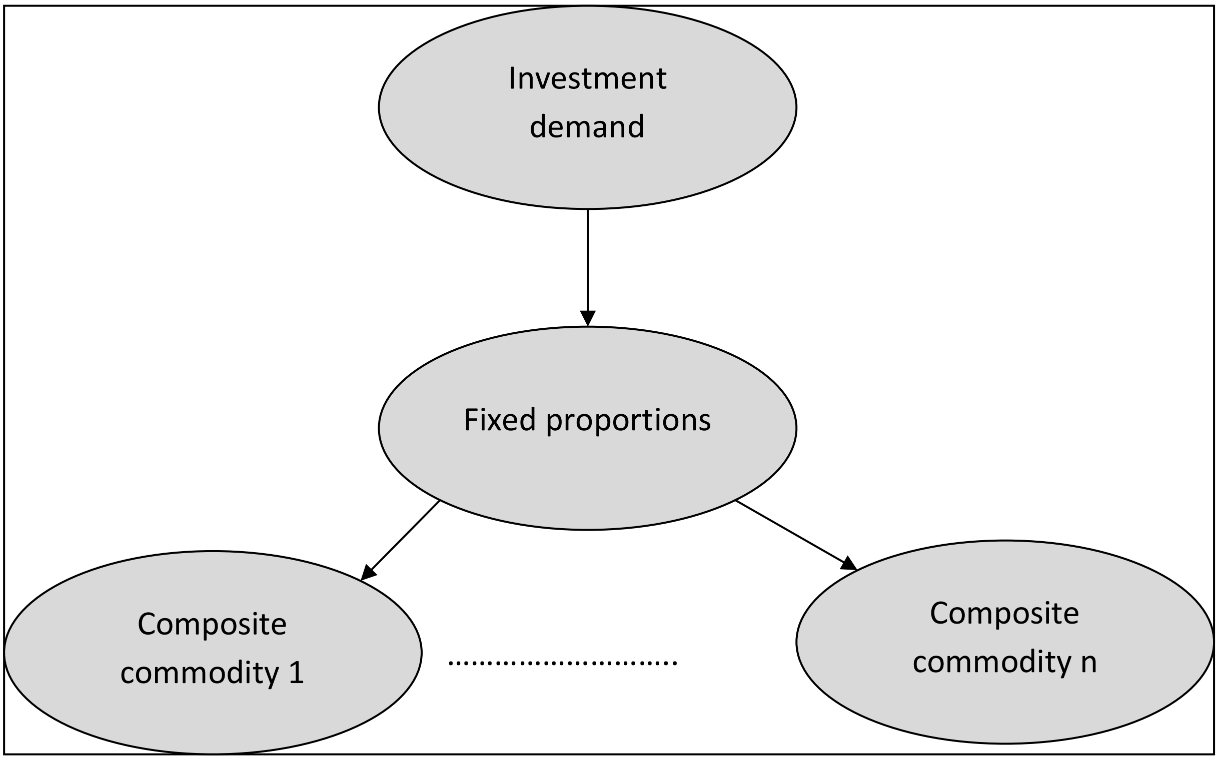
(1) $$Inv_{r,t} = Y_{r,t} \times \exp\left\{\rho_r\left[\beta_r\left(R^e_{r,t} - R^w_t\right)\right]\right\}$$

A further assumption made is that investors use static (rather than forward looking) expectations. In this case, $R^e_{r,t}$ simply becomes the rate of return in region r at time t ($R_{r,t}$).

Investment goods

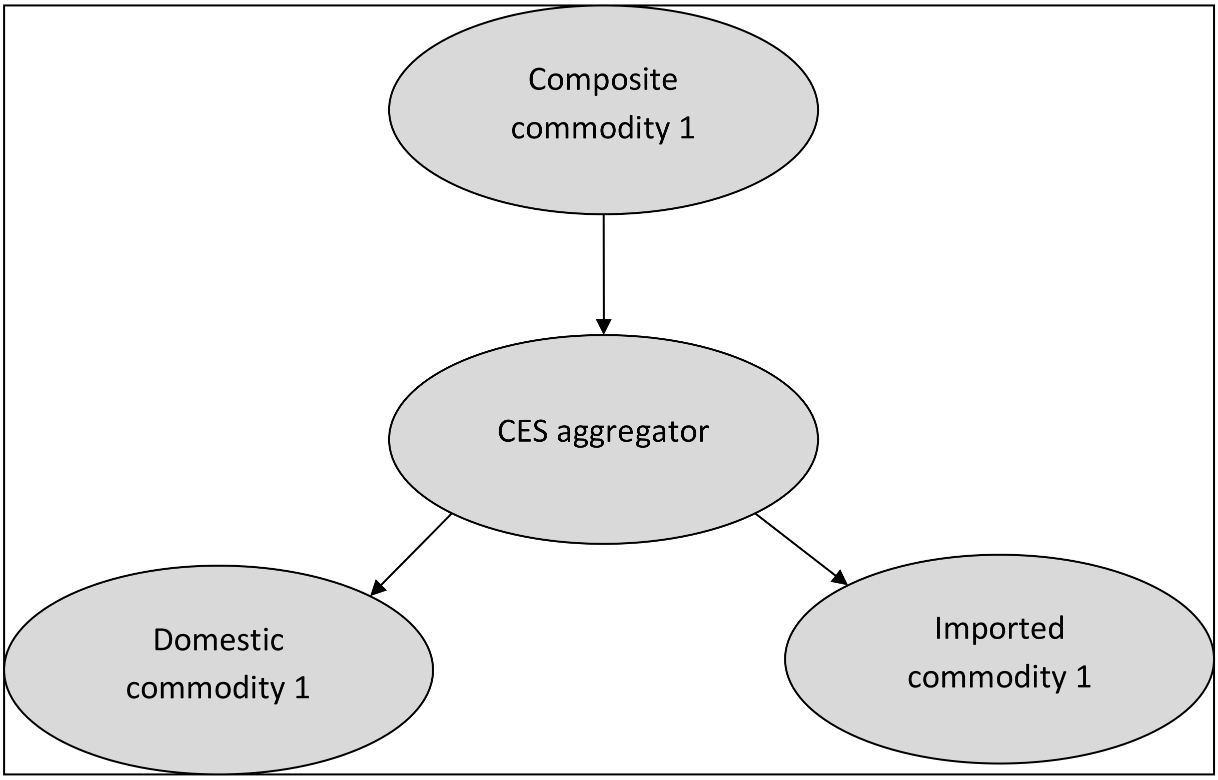
Once the aggregate amount of investment is determined, the investor then purchases goods and services to produce capital units. Investment 'goods' are usually construction services and heavy machinery. At the first stage, the investor is assumed to purchase composite investment commodities in fixed proportions (Figure 10).

Figure 10: Demand for composite investment goods



The cost of investment in then minimised by substituting domestic and imported goods and services using a CES function (Figure 11).

Figure 11: Demand for domestic and imported investment goods



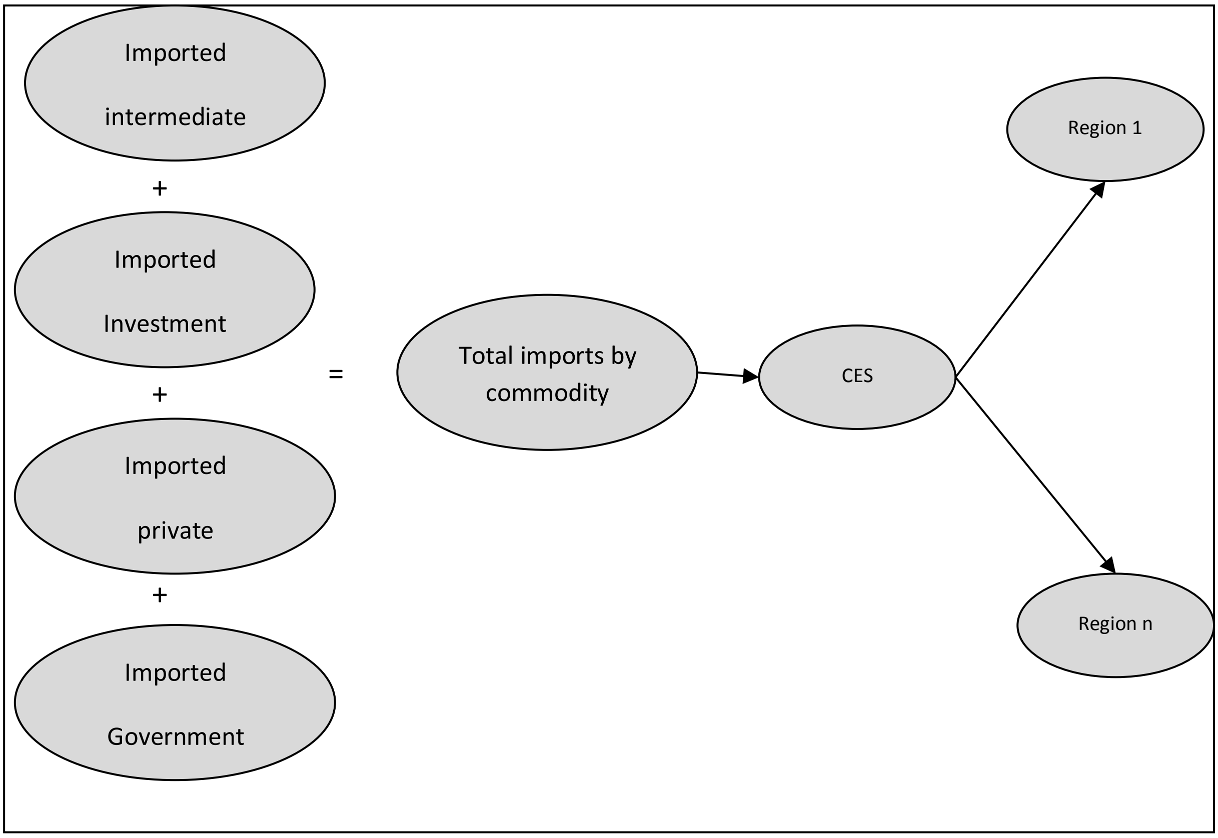
Margin demand

Goods are transported between regions by an international transport industry. The basic assumption that determines the demand for international transport is that it is proportional to the flow of goods being transported from one region to the other. In other words, the percentage change in demand for transport service per unit of good transported between any two regions is set equal to the percentage change in the quantity of commodity transported.

Bilateral trade

The model accounts for bilateral trade. An aggregate amount of imports are determined by commodity, and each region substitutes between supplying regions again based on the Armington assumption (Figure 12).

Figure 12: Determination of imports by source



Supply side

The model is of the general form:

$$Y = \alpha f(g_f)$$

where output *Y* is a function of productivity (α) and the supply of factors of production (g_f).

Factors of production

Capital, land, labour and natural resources are the four primary factors of production in the model. Both capital and labour are mobile between industries. Capital is mobile across regions through international movements of investable funds (although capital stock cannot migrate).

Natural resources are coal, oil, gas, non-metallic minerals, fish and forestry; and land is mobile within agricultural sectors with a small coefficient of constant elasticity of transformation.

Capital Stock

The capital stock in each region (country or group of countries) accumulates by investment less depreciation in each period. Its supply in each period is determined by the depreciated capital stock of the last period and gross investment undertaken over the last period.

Labour

The supply of labour is positively influenced by movements in the wage rate governed by an elasticity of supply. This implies that changes influencing the demand for labour, positively or negatively, will impact both the levels of employment and wage rate. This is a typical labour market specification for a dynamic model such as CEGEM. There are other labour market 'settings' that can be used. First, the labour market can take on long-run characteristics with aggregate employment being fixed and any changes to labour demand changes being absorbed through movements in the wage rate. Second, the labour market can take on short-run characteristics with fixed wages and flexible employment levels.

Land

Land is generally assumed to remain fixed in a CEGEM simulation. Land may move from one industry to another in pursuit of higher rates of return and in response to changes in their scale of operation, but only rather slowly. This relation is the result of maximizing the total return from land ownership subject to a CET constraint defined over the quantity of land allocated to various agricultural sectors and a given supply.

Natural resources

CEGEM explicitly models natural resource inputs as a factor of production in resource based sectors (coal mining, oil and gas extraction, other minerals, forestry and fishing). For example, the coal mining industry utilises three factors of production . labour, capital and a natural resource (reserves of coal). The natural resource is a factor used solely in the production of resource based commodities and is not mobile between sectors or regions with exogenous supply.

It is assumed that returns to the natural resource adjust to maintain its full employment. If, for example, the demand for coal were to decline, returns to the natural resource (its price) would fall, leading to a reduction in the supply price of coal.

Technological change

The model contains provision for simulating the impacts of various types of biased and neutral technical change. It may be interesting to note that the standard definitions of the biases in technological change used in economics apply to a static situation where input prices are fixed. In general equilibrium models, however, technological changes introduced in any form inevitably lead to changes in relative prices. Consequently, demand for various inputs may be affected accordingly. A technological change that may be unbiased at the industry level in a partial equilibrium setting may turn out to be 'biased' in terms of its impacts in a general equilibrium model. In this sense, it is very difficult to define an episode of neutral technical progress that eventually ends up being input-neutral in a general equilibrium model.

It is nevertheless possible to focus on the impact of the technical change on input demand before the whole system gets adjusted. It is this impact that has been taken to identify the nature of a technical change in CEGEM, whether it is a neutral technical progress at regional or sectoral level or a technical progress that is biased towards saving some specific input in a specific industry. An input neutral technical progress increases the output that can be obtained from a given level of inputs and biased ones reduce specific input demand for a given level of output.

Provisions are made in CEGEM for different types of technical changes that are commonly used in standard simulations of the model. The main idea is that either the technical change operates through level of output (if it is input neutral) or it operates through altering input demands if it is biased in nature. It is important to note that these technical change variables have been appropriately included into the input demand, price links and zero profit conditions to capture the market effects of the technical change.

Price links

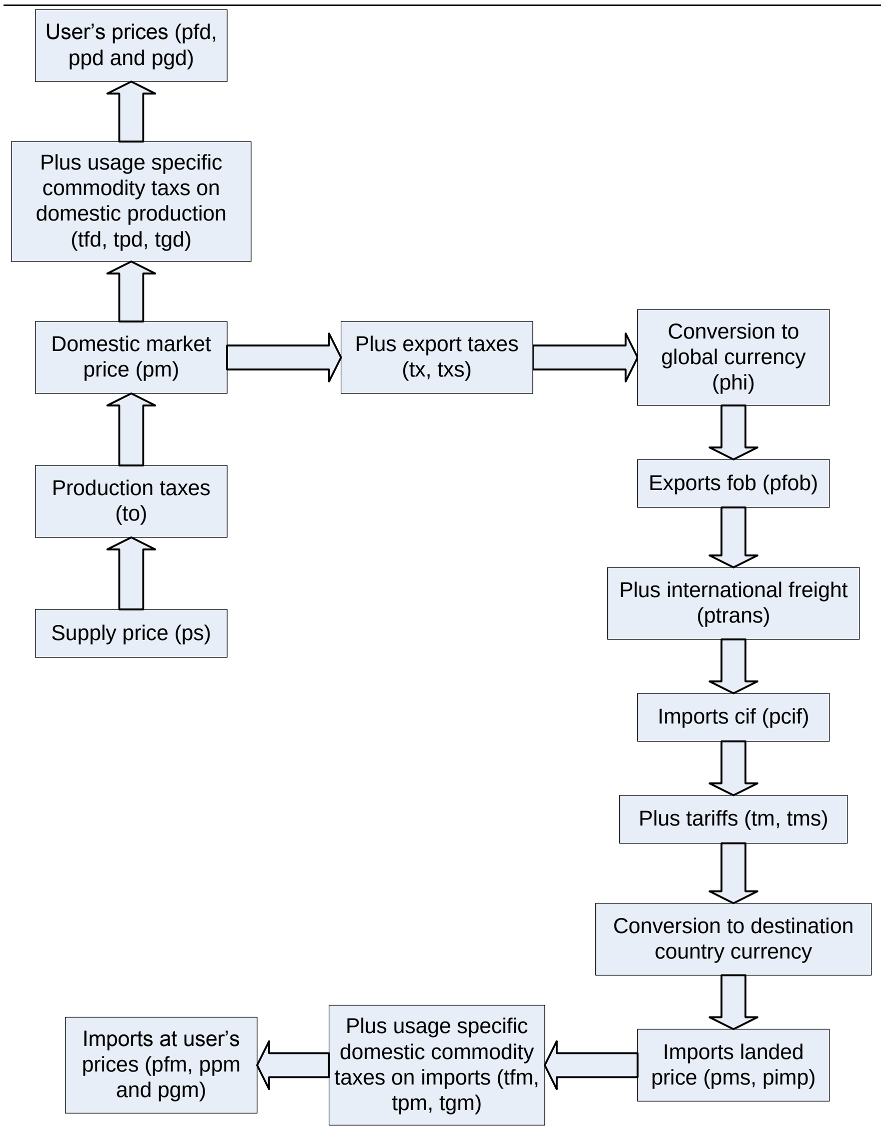
For each good and primary factor, taxes on production, sales, exports and imports are accounted for separately. As a result, for a given good, the supply price, market price, domestic users price and fob price of a commodity in the producing region and the cif price, duty paid market price and user prices in the importing region of a given commodity are clearly distinguished.

Figure 13 demonstrates the price formation across regions. It starts with supply prices in the source region (*ps*), to which production taxes (*to*) are added to give domestic market prices (*pm*). Goods that are being exported then have export taxes added to them (*tx* for non destination specific taxes, *txs* for destination specific taxes) to produce fob prices (*pfob*) after conversion to global currency using the exchange rate *phi*.

Freight is then added to calculate imports at cif prices (*pcif*). To which tariffs are added (*tm* for non source specific tariffs, *tms* for source specific tariffs) and then converted to the local currency of the importing region using *phi* to derive landed duty paid import prices (*pms*). Any additional commodity taxes specifically levied on imports for particular users are added (*tfm* for intermediate usage and investment, *tpm* for household consumption and *tgm* for government consumption) to determine import prices for individual users. These prices are *pfm* for intermediate inputs and investment, *ppm* for household consumption and *pgm* for governments.

If a commodity is not exported, then domestic commodity taxes for various users (*tfd* for intermediate inputs and investment, *tpd* for household consumption and *tpg* for government consumption) are simply added to give domestic user prices. These prices are *pfd* for intermediate inputs and investment, *ppd* for household consumption and *pgd* for governments.

Figure 13: Price formation in CEGEM0



Foreign exchange market

CEGEM expresses all domestic prices in local currencies of the region and international prices in units of (hypothetical) global currency. The exchange rates in CEGEM are the prices of the global currency in terms of local currencies. Although CEGEM distinguishes regional currencies, it does not have the necessary equations describing the demand and supplies of regional currencies. The task of price determination is thus left for the closure. When all agents in all regions satisfy their budget constraint, the balance of payments of each region necessarily balances. As the balance of payments show the demand and supply of currencies, this result also implies that currency markets will automatically remain in equilibrium.

In the absence of a fully specified money market, one of the prices cannot be determined as one market clearing condition has to be dropped out to solve the system and that price has to be set exogenously. This means that the commodity whose price has been exogenously set (and say chosen to be one) is indistinguishable form the regional currency, provided we assume that the target of monetary policy is to keep the price of the numeraire constant. CEGEM, currently works in this mode. One price for each region, which in standard model closure is chosen as the regional CPI, is taken as the target of regional monetary policy and the global price of savings is taken as the target of global monetary policy. Hence the price of a unit of global savings, which is the average global investment good, in terms of regional CPI bundles is defined as the regional exchange rates. Users who do not like to use the exchange rate mechanism may choose to fix the regional exchange rates and allow regional CPIs to vary, while keeping one of the global prices, such as the global price of savings, fixed. This will yield the same real solution for any given counter-factual simulation of the model.

When the exchange rates are allowed to vary, one can argue that the exchange rate in each region is the price that adjusts to keep the foreign exchange market (or the balance of payments) in equilibrium. For example, if the imposition of a carbon equivalent penalty that leads to a significant decline in oil export earnings from a particular region, this will (all other things being equal) result in an exchange rate depreciation for that region. The depreciation in the exchange rate will improve the competitiveness of exporters and import competing producers in that region. Exports will increase and imports decline, restoring the balance of payments equilibrium. This argument has to be understood in the context that the price that keeps the market clearing is the movements in the real exchange rate, not the nominal one.

As the model assumes the existence of global and regional currencies, it is important to specify how they fit into the system of general equilibrium. It is assumed in CEGEM that monetary policy in each region targets regional CPIs and the supply of global currency is targeted to the price of the global numeraire. The exchange rates therefore reflect the barter terms of trade between the global numeraire, which is the average unit of global investment, and the regional numeraires, which are bundles of consumer goods. The ratios of exchange rates of regional currencies against the global currency give the matrix of bilateral exchange rates, which are the barter terms of trade between the CPI bundles of the regions. Hence the relative change in the CPIs of the region in the absence of the exchange rate is captured by the movement in the GTEM exchange rates in which CPIs are held fixed by the choice of the closure. The variable *phi* in equations determining various price indices, price links and zero profit conditions gives the regional exchange rates of the global currency and are determined by the equation for the regional CPIs.

Equilibrium conditions

The basic assumptions in CEGEM can be shown to be consistent with the general conditions for the existence of equilibrium. Maximising decisions by agents throughout the global economy determine the demand and supply for commodities and primary factors by region at given prices. Prices at different levels throughout the global economy adjust to ensure equality of demand and supply. Equilibrium in CEGEM is achieved through a series of market clearing equations and the zero pure profit condition.

In CEGEM a large number of equilibrium conditions are imposed, reflecting various market clearing conditions. With some exceptions, maximising decisions by agents throughout the global economy determine the demand for and supply of commodities and primary factors by region at given prices. Prices at different levels throughout the global economy adjust to ensure equality of demand and supply. Hence the market clearing conditions are identified with respective prices. The period of adjustment is usually taken to be one year. Firms earn zero pure profits in equilibrium.

In the factor markets, labour is a homogeneous commodity within each region. Although net migration occurs in CEGEM, these flows are not responsive to regional differences in wage rates. Capital and labour are mobile across industries with the region therefore they have regional market clearing conditions. Land is a sluggish commodity. Although it has a regional market clearing condition, prices can vary across industries as the supply of land to each industry responds to price differently. Natural resources are taken to be sector specific and thus have market-clearing conditions specified at industry level.

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