Open Economy Extensions

Trade in SOE: The Basics

Single-country modeling of an open economy requires the specification of trade links with the international market. The foreign closure of a single-country model is typically done by specifying four sets of functions:

- import demand
- import supply
- export demand
- export supply

The specification of these functions depends on different assumptions such as:

- product heterogeneity in trade (Armington assumption) versus product homogeneity (Heckscher-Ohlin assumption)
- exogenous world prices (domestic price taking behavior - small open economy assumption) or endogenous world prices (levels of trade affecting the terms of trade - large open economy)

Trade in SOE: Fixed Trade Flows

Simplest trade representation: All trade quantities (exports and imports) are exogenous.

- MPSGE implementation:
  - Include a vector of commodity imports minus exports through the endowment set of an agent.
  - Depending on the sign of the sum of trade flows, this agent receives or pays foreign exports.

  $DEMAND: CONS
  E:P(S) Q:M0(S) - X0(S)

- This approach ignores changes in international prices and their effects on the balance of payments.

- Foreign trade effects can be investigated parametrically, which assures "control power" of the modeler (i. e. nebulous or arbitrary trade elasticities do not drive the results).

Endogenous Trade: Balance of Payment

Endogenous trade specification involves an explicit "balance of payment" (BOP) constraint which assures trade balance.

- This constraint must be imposed in the single country model (note that in a multi-region trade model the BOP constraint is implied by Walras' law).

- In MPSGE, an artificial commodity ("foreign exchange") is introduced. The SOE gets “foreign exchange” for exports of domestic goods and uses it for imports of foreign goods.

- The price associated with the foreign exchange commodity is something like the "exchange rate". The exchange rate is simply an accounting device and no monetary instrument in a real model (without monetary sector).

Foreign closure implies that the market for this good is cleared:

$$\sum_{i \in I} p_i^X \; X_i = \sum_{i \in I} p_i^M \; M_i + BOP$$

where:

X_i,M_i:	is the export/import quantity of good i,
P_i^M,P_i^X:	are the world market import and export prices for good i
BOP	benchmark BOP deficit or surplus

Trade: SOE Assumption

Small open economy assumption:

- The economy is considered small relative to the world market.
- Export demand and import supply curves are horizontal - international prices are fixed. The effects of exports and imports on international prices can be ignored.
- Any import demand of the small country is met at fixed world market prices and any export supply is sold at fixed world market prices. It is not necessary to include an explicit export demand and import supply function within the model formulation.

Trade: Heckscher-Ohlin Assumption

- Domestic and international commodities are treated as perfect substitutes.

- In MPSGE, the HO approach is implemented by using two linear activities for import demand and export supply (assuming net trade):

  - Commodity i's import activity uses foreign exchange inputs of P_i^M units to produce 1 unit of good i as output.

  - The corresponding export activity consumes 1 unit of good i and produces (earns) P_i^X units of foreign exchange.

- Problems in linear trade formulation:
  - no cross-hauling of data (simultaneous imports and exports of the same good)

  - extreme effects due to linear trade formulation

    Sidesteps to cope with this problem include: imperfect substitution between domestic and international goods (see below: Armington assumption), sector-specific factors or elastic world prices (see below: elastic export demand and

Example: SOE - HO Trade

File: M4_1S

```
$ontext
                Production Sectors                          Consumer

Markets   |     X1      X2      E1      M2      W       CONS
-----------------------------------------------------------------
P1        |     150             -50             -100
P2        |             50              50      -100
PL        |     -100    -20                             120
PK        |     -50     -30                             80
PW        |                                     200     -200
PFX       |                     50      -50
-----------------------------------------------------------------

$offtext

SCALAR          PE2     Export price of good 2 / 0.99/
                PM1     Import price of good 1 / 1.01/
                PE1     Export price of good 1 / 1   /
                PM2     Import price of good 2 / 1   /
                TM2     Import tariff for good 2 / 0/;
$ONTEXT

$MODEL:M4_1S

$SECTORS:
        X1      ! Production index for good 1
        X2      ! Production index good 2
        E1      ! Export level of good 1
        E2      ! Export level of good 2
        M1      ! Import level of good 1
        M2      ! Import level of good 2
        W       ! Welfare index

$COMMODITIES:
        P1      ! Price index for good 1
        P2      ! Price index for good 1
        PFX     ! Read exchange rate index
        PW      ! Welfare price index
        PL      ! Wage index
        PK      ! Capital rental index

$CONSUMERS:
        CONS    ! Income level for representative agent

*       Cobb-Douglas production in both sectors:
$PROD:X1  s:1
        O:P1    Q:150
        I:PL    Q:100
        I:PK    Q:50

$PROD:X2  s:1
        O:P2    Q:50
        I:PL    Q:20
        I:PK    Q:30
```

Example: SOE - HO Trade (continued)

File: M4_1S

```
*       We scale the export price for good 1 and the import price
*       for good 2 to both be unity:

$PROD:E1
        O:PFX   Q:PE1
        I:P1    Q:1

$PROD:M2
        O:P2    Q:1
        I:PFX   Q:PM2    A:CONS T:TM2

*       The following trade activities are not operated in the benchmark
*       period:

$PROD:E2
        O:PFX   Q:PE2
        I:P2    Q:1

$PROD:M1
        O:P1    Q:1
        I:PFX   Q:PM1

*       Cobb-Douglas preferences:

$PROD:W   s:1
        O:PW    Q:200
        I:P1    Q:100
        I:P2    Q:100

$DEMAND:CONS
        D:PW    Q:200
        E:PL    Q:120
        E:PK    Q:80

$OFFTEXT
$SYSINCLUDE mpsgeset M4_1S

*       We replicate the benchmark by assuming default values of
*       unity for production activities and prices, but we must
*       explicitly specify benchmark values for the trade activities
*       because they are not unity:

E2.L = 0;
M1.L = 0;
E1.L = 50;
M2.L = 50;

M4_1S.ITERLIM = 0;
$INCLUDE M4_1S.GEN
SOLVE M4_1S USING MCP;
M4_1S.ITERLIM = 2000;
```

Trade: Armington Assumption

- Domestic and international goods are imperfect substitutes on the import and/or export markets. This avoids unrealistic specialization and reflects cross-hauling of data.

- Aggregation functions can be used to characterize Armington imports and exports.
  - domestic-export output transformation (e. g. CET: ε):

$$Y_i = \left(\alpha_i^D \; D_i^{\frac{\varepsilon_i - 1}{\varepsilon_i}} + \alpha_i^{EX} \; EX_i^{\frac{\varepsilon_i - 1}{\varepsilon_i}} \right)^{\frac{\varepsilon_i}{\varepsilon_i - 1}}$$

  - domestic-import substitution possibilites (e. g. CES: σ):

$$S_i = \left(\beta_i^D \; D_i^{\frac{\sigma_i^{IM} - 1}{\sigma_i^{IM}}} + \beta_i^{IM} \; IM_i^{\frac{\sigma_i^{IM} - 1}{\sigma_i^{IM}}} \right)^{\frac{\sigma_i^{IM}}{\sigma_i^{IM} - 1}}$$

- In MPSGE, an Armington good for the domestic market is conveniently specified as a separate production activity. Armington exports are represented through an additional output field in sectoral production (incl. a t-field for specifing the transformation elasticity).

Example: SOE - Armington Trade

File: armtrade.gms

```
$ontext
Production Sectors                      Consumer
Markets   |     X1      X2      E       M        W       CONS
-----------------------------------------------------------------
P1        |     150             -100    50      -100
P2        |             50      -25     75      -100
PL        |     -100    -20                             120
PK        |     -50     -30                              80
PW        |                                     200    -200
PFX       |                     125     -125
-----------------------------------------------------------------
$offtext


$ONTEXT

$MODEL:arm

$SECTORS:
        X1      ! Production index for good 1
        X2      ! Production index good 2
        AM1     ! Armington import index for good 1
        AM2     ! Armington import index for good 2
        W       ! Welfare index

$COMMODITIES:
        P1      ! Price index for good 1
        P2      ! Price index for good 1
        PA_1    ! Price index for imported good 1
        PA_2    ! Price index for imported good 2
        PFX     ! Read exchange rate index
        PW      ! Welfare price index
        PL      ! Wage index
        PK      ! Capital rental index

$CONSUMERS:
        CONS    ! Income level for representative agent

*       Cobb-Douglas production in both sectors:

$PROD:X1  t:2     s:1
        O:P1    Q:50
        O:PFX     Q:100
            I:PL    Q:100
        I:PK    Q:50


$PROD:X2  s:1
        O:P2    Q:25
            O:PFX Q:25
        I:PL    Q:20
        I:PK    Q:30
```

Example: SOE - Armington Trade (continued)

File: M4_15

```
$PROD:AM1
        O:PA_1  Q:100
        I:PFX   Q:50
            I:P1  Q:50

$PROD:AM2
        O:PA_2   Q:100
        I:PFX    Q:75
            I:P2   Q:25

*       Cobb-Douglas preferences:

$PROD:W   s:1
        O:PW    Q:200
        I:PA_1  Q:100
        I:PA_2  Q:100


$DEMAND:CONS
        D:PW    Q:200
        E:PL    Q:120
        E:PK    Q:80

$OFFTEXT
$SYSINCLUDE mpsgeset arm

arm.ITERLIM = 0;
$INCLUDE arm.GEN
SOLVE arm USING MCP;
```

Trade: Export Demand and Import Supply Functions (LOE)

- In many models, CES export demand and import supply functions are employed: The single country faces a downward sloping demand for exports and an upward sloping supply for imports.

- In MPSGE, the specification of CES export demand and import supply functions is accommodated through the use of constraints. To assure trade balance, an additional constraint is necessary with the shadow price being the exchange rate.

```
*       Import supply function:

$CONSTRAINT:M(I)$M0(I)
        M(I) =E= (P(I)/PFX)**(0.12);

*       Export demand function:

$CONSTRAINT:X(I)$X0(I)
        X(I) =E= (P(I)/PFX)**(-10);

*       Balance of payments constraint:

$CONSTRAINT:PFX
        SUM(I, P(I) * X(I) * X0(I)) =G= SUM(I, P(I) * M(I) * M0(I));

*       Associated endowment fields:

E:P(I)    Q:M0(I) R:M(I)
E:P(I)    Q:X0(I)  R:X(I)
```