

Chapter 3: Appendix

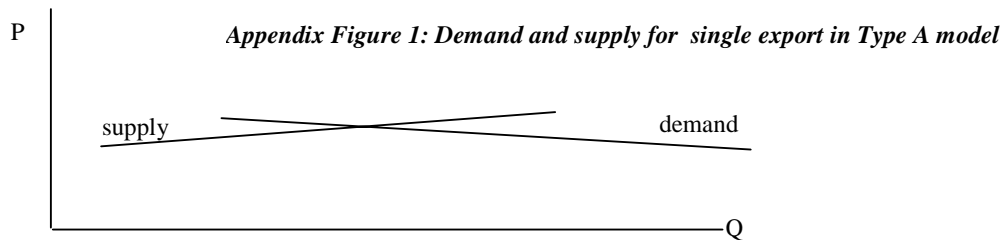
Shocking a Single Country CGE Model with Export Prices/Quantities from a Global Model

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This appendix explores the following problem: suppose a GTAP simulation has produced percent changes in import and export quantities and border prices for a particular country, say Brazil. How do we apply the GTAP results to a single country CGE model of Brazil (assuming it has the same commodity aggregation as the GTAP simulation)? In discussing this issue, we will distinguish between the two most common types of single country CGE models: models where exports and domestically produced goods are perfect substitutes (Type A) and those where they substitute only imperfectly (Type B).

1 Type A single-country CGE model

The Type A single-country CGE model has capital and labour mobile among sectors, and export goods are identical to those domestically used. In Type A models, individual export supply functions tend to be very flat, especially for non-primary goods. The (small) slope derives from economy-wide factor constraints and, perhaps, sector-specific fixed factors such as land.

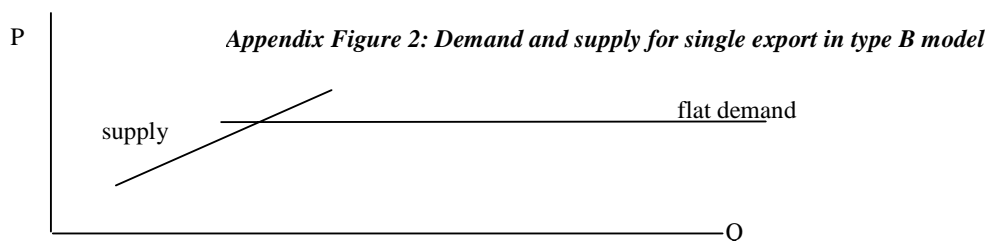


Some slope is needed for export demand functions in the Type A model. If export prices were fixed (small country assumption), quite small shifts in supply functions could cause export quantities to fluctuate wildly (the over-specialization or flip-flop problem). Indeed, at first order, each commodity price will be a share-weighted average of the prices of factors or imports. Hence, with more goods than factors (and import prices fixed), not all export prices can vary independently. Thus, in a Type A model, attempts to exogenously fix all export prices will fail or will simply produce ridiculous results. To prevent this problem, Type A models usually postulate a downward-sloping constant-elasticity demand curve for each export good, as shown in Figure 1. This means that export expansion will be accompanied by falling export prices and a terms-of-trade loss. Indeed, at modest tariff levels, this terms of trade loss

will dominate the efficiency gains obtained from unilateral tariff reduction, so that aggregate welfare will fall. This is simply evidence of a non-zero optimal tariff.

2 Type B single-country CGE model

In a Type B single-country CGE model, export prices are **not** identical to prices of domestically used goods. The two are related via a CET transformation frontier. This gives individual export supply functions a marked upward slope. Type B models are therefore compatible with fixed export prices (the small country assumption) and therefore zero optimal tariffs.



Since for each good, the export price is related to the export/domestic quantity ratio for that good, we can shock export prices independently and export quantities will adjust to suit.

Both types A and B models normally assume that CIF import prices are fixed, and that users substitute between imports and domestic goods via a CES nest, with the ease of substitution governed by a so-called “Armington” elasticity. Therefore, there is no difficulty about shocking import prices. Here we concentrate on the problem of how to shock exports.

3 Single country within GTAP

The individual countries (or regions) embedded within the GTAP model are akin to Type A models (there is no export/domestic CET). The downward slope on export demand schedules derives from the Armington assumption applied in *other regions*. Indeed the export demand elasticity for good i facing a country with small world market share will be approximately equal to the (inter-import) Armington elasticity of substitution. So in the global model, the import and export demand elasticities are inextricably inter-twined.

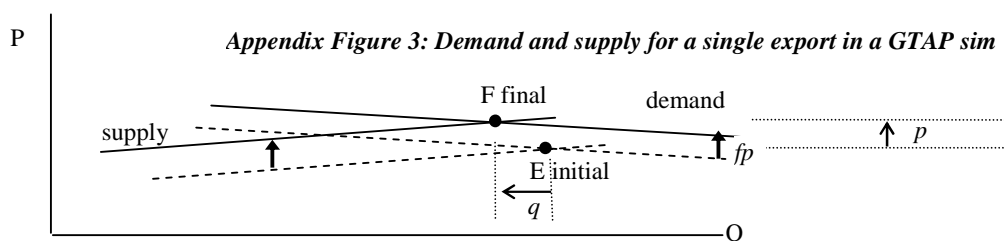


Figure 3 shows how shifts in export supply and demand schedules lead to observed changes in price (p) and quantity (q). Here, we focus on the vertical shift in the demand schedule, fp , as that will prove crucial in our subsequent methodology. Note that fp is **not** equal to the price change p . Depending on the supply shift, p and fp may even be of opposite sign. Secondly, note that even if the GTAP simulation shows only the effect of **other** countries' actions, we would still expect the supply curves to shift, since all sectors use the same mobile factors and an expansion of economic activity in another sector will raise production costs in the focus sector.

4 What should GTAP communicate to the single country model ?

In using GTAP to drive a single country model, should we attempt to match the GTAP export prices or quantities, or both of these? Our aim is to let the single country model determine export supply behaviour, and to take world demand changes from GTAP. From Figure 3 we can see that the GTAP export prices and quantities *are simultaneously determined* by the slopes and shifts of the GTAP export *demand and supply* curves. We would not expect the same results if the GTAP supply behaviour were replaced by a supply curve from another, single-country model. Rather, the numbers to take from GTAP are the slope and shift (fp) of the world demand schedule. Of course there are alternative methods of communicating the global model results to the national models. We experimented with many of these and found them deficient in one way or another.¹

5 Calculating the vertical shift in the GTAP export demand curve

If we know export prices and quantities from a GTAP simulation, and the slope of the export demand curve, we can calculate fp , the vertical shift in the demand curve, as follows.

The GTAP export demand curve can be written:

$$Q = [FP/P]^{ESUBM}$$

and $ESUBM$ is the (positive) slope of the demand curve, approximately equal to the GTAP elasticity of substitution among imports. In proportional [log-change, percent] form this becomes:

$$q = -ESUBM*(p - fp)$$

or
$$p = fp - q/ESUBM$$

where lower case variables denote percentage changes in their upper case counterparts.

Hence
$$fp = p + q/ESUBM$$

¹ For instance, the most obvious thing would be to simply perturb the export demand schedule (Type A model) or the export price (Type B model) by the amount of the GTAP price change. However, as will be seen below, this produces perverse results in the Type A model case, as fp and p frequently move in opposite directions. In the Type B model, this produces reasonable price changes, but can produce quantity changes that are far too small. Other strategies involve imposing some sort of technical change or export tax/subsidy in the national model, but these have undesirable welfare consequences.

Suppose the country model for (e.g.) Brazil was Type A, was based on the same input-output table as used for the GTAP database, used the same factor mobility assumptions as GTAP, and used the same trade elasticities. Further suppose that the export demand elasticities were equal to the GTAP inter-country elasticity of import substitution. In short suppose that the Brazil model was essentially the same as the Brazil part of GTAP. Then we would expect that appropriate shocks to FP would produce very similar price and quantity changes to GTAP.

In practice, the similarity criteria just listed will not all be satisfied. Thus, taking from GTAP the slope and shift (fp) of the world demand schedule, will yield export prices and quantities different to the GTAP simulation. That indeed could be desirable, if we felt that the Brazil single-country model represented Brazil better than the Brazil part of GTAP. And this is the operating assumption used in this book.

6 Summary of recommended approach

6.1 For type B models, add an export demand curve for each good

Mimic the GTAP export demand curve by adding for each exported good the equation:

$$Q = [FP/P]^{ESUBM}$$

Type A models already have such an equation: the elasticity, $ESUBM$, should be taken from GTAP.

6.2 The shock from GTAP is a change in FP (export demand curve shift)

Given $ESUBM$, and percent changes q and p from the GTAP simulation we can compute the percent change fp , at first order as:

$$fp = p + q/ESUBM$$

or exactly as:

$$fp = 100*[a - 1] \quad \text{where} \quad a = [1 + 0.01*p] * ([1 + 0.01*q]^{1/ESUBM})$$

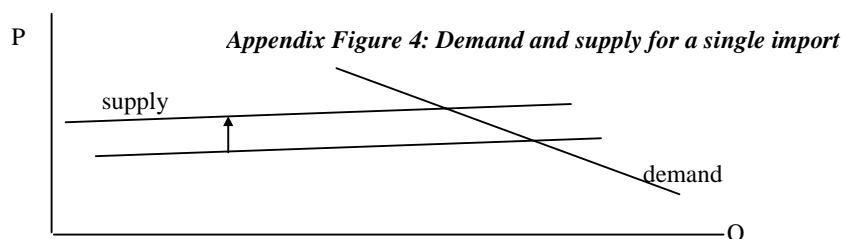
6.3 Tailor the single-country to resemble the GTAP simulation and model.

This includes choosing the trade elasticities, closure and method of tax redistribution that matches the GTAP treatment. For type B models, the CET should be set to a high value, or eliminated altogether, since the role it has played (to prevent flip-flopping of results) is no longer necessary.

7 What about the import side?

We could make a similar argument about import prices and quantities: GTAP presents upward-sloping import supply curves to the single-country, and GTAP changes in import prices and quantities are again simultaneously determined by world import supply curves (which we want to borrow from GTAP) and GTAP import demand curves (which we want to replace with those from our own single-country model). Should we indeed mimic and shift the

GTAP import supply curve? No. It seems that merely shocking import prices is likely to be adequate, since, in GTAP, the import supply curves to a small country really are very flat, and in all the models the import demand curves (which use the import-domestic Armington elasticities) are comparatively steep. Hence, vertical shifts in import supply are well proxied by exogenous price changes (see Figure 4 below).



8 Numerical Examples

Tables 1 and 2 below illustrate some of the above points using results from a GTAP "Doha-All" simulation driving single-country models for Brazil and China. The rows, corresponding to commodities, are ordered by the initial value of exports in GTAP. The table shows percent price and quantity changes from the GTAP simulation, and the implied shift in the GTAP export demand curve, assuming that it has slope dictated by GTAP's Armington elasticity of substitution. These tables also report resulting percent price and quantity changes from the single country models. Import prices were also shocked but are not shown in the table. (The focus country's tariffs were not changed for this simulation.)

Several points are worth making about the tables. First of all, the GTAP price change is indeed a poor proxy for the GTAP demand shift. Secondly, the prices and quantities from the single country model—while highly correlated with those from GTAP—are rather different in magnitude (and sometimes sign) because supply behaviour is different in the two models. The correlation is higher for the changes in quantities (0.87 for both countries) than for the changes in prices (0.7 for Brazil and 0.61 for China).² Nevertheless, if we think the single country model best describes the particular country, and world demand changes are well summarized by the demand shift in the global model, then the single country model price and quantity changes are the best estimates available.

² The relatively smaller correlation for China's prices is likely due to the fact that this model retained the CET assumption on exports (Type B model), whereas the Brazil model dispensed with this assumption as per the preferred approach outlined above.

Appendix Table 1: Interaction of GTAP with Brazil model

Sector	Price change (GTAP)	Export change (GTAP)	Demand shift (GTAP)	Price change (model)	Export change (model)	Export values (GTAP)	Elasticity of substitution (GTAP)
Automobiles	1.5	-3.6	0.9	0.7	1.0	5316.9	5.6
ElectricMat	1.8	-11.9	0.3	0.8	-4.1	5250.6	8.8
EnterpServ	2.2	-8.3	-2.2	0.9	-6.1	4475.9	2.0
ChemicElem	1.6	-8.9	0.2	0.9	-4.2	4289.6	6.6
OthFood	2.4	-0.6	2.2	0.8	5.9	3969.1	4.0
MineralExtr	1.1	-1.4	0.4	0.9	-1.0	3833.8	1.8
Soybean	3.8	-9.6	1.7	2.1	-1.7	3747.7	4.9
MachTractor	1.8	-15.2	-0.7	0.8	-10.0	3656.9	6.7
IronProduc	1.7	-8.4	0.2	0.8	-3.3	3352.2	5.9
OtherAgric	3.8	-19.0	-0.4	-0.1	-1.7	3250.7	5.0
Slaughter	5.0	169.7	17.6	7.8	102.5	2714.7	8.8
ShoesInd	2.1	-15.6	0.0	1.5	-11.8	2537.0	8.1
EletronEquip	1.4	-9.9	0.2	0.7	-4.0	2513.6	8.8
PaperGraph	1.8	-9.8	0.0	0.8	-4.6	2502.6	5.9
WoodFurnit	2.0	-10.3	0.4	0.8	-2.7	2248.6	6.8
MetalNonFerr	1.4	-6.3	0.6	0.8	-1.4	2185.0	8.4
Transport	1.6	-6.0	-1.5	0.8	-4.5	1635.0	2.0
SugarInd	2.7	4.6	3.6	1.2	13.0	1435.0	5.4
MinNonMet	1.8	-5.3	0.8	0.9	-0.7	1320.3	5.8
Textiles	1.8	-7.2	0.8	0.7	0.3	906.3	7.5
OtherMetal	1.8	-10.3	0.2	0.8	-4.3	762.0	7.0
Trade	2.0	-7.2	-1.8	1.0	-5.5	713.8	2.0
PublAdm	2.0	-7.6	-2.0	0.9	-5.8	700.7	2.0
Corn	5.1	10.5	9.2	1.8	19.8	690.9	2.6
VariousInd	1.9	-14.6	-0.4	1.0	-9.1	671.7	7.0
FinancInst	2.0	-7.9	-2.1	0.8	-5.7	636.2	2.0
VegetOils	2.8	-2.3	2.5	1.5	6.5	521.3	6.6
PetrolRefin	0.5	-1.0	0.3	0.8	-2.0	407.9	4.2
Comunic	2.1	-8.0	-2.1	0.9	-5.9	284.5	2.0
Apparel	1.8	-8.1	0.7	0.9	-1.5	243.0	7.4
FamServic	2.0	-7.8	-2.1	1.3	-6.5	173.6	2.0
Cotton	4.0	-13.4	1.1	-1.4	12.9	173.3	5.0
Poultry	5.5	-12.3	0.3	8.6	-19.6	170.0	2.6
CoffeeInd	2.2	-2.3	1.2	0.7	1.1	76.0	2.3
Dairy	3.0	35.9	7.4	0.7	55.8	30.6	7.3
CivilConst	2.1	-7.8	-2.0	1.0	-5.8	30.2	2.0
PetrGasExtr	0.3	-2.8	-0.1	0.9	-7.8	16.7	8.0
Livestock	8.3	-22.8	1.5	13.8	-39.8	5.3	4.0
PaddyRice	4.6	17.6	6.3	1.0	61.2	2.1	10.1
NaturMilk	4.9	-31.9	-13.4	0.4	-26.2	1.1	2.0
Wheat	3.5	-17.1	1.3	1.6	-2.3	0.8	8.9
SugarCane	4.2	18.0	7.7	1.7	32.2	0.0	5.0
BuildRentals	2.4	0.3	2.6	1.0	3.1	0.0	2.0

Appendix Table 1: Interaction of GTAP with China model

Sector	Price change (GTAP)	Export change (GTAP)	Demand shift (GTAP)	Price change (model)	Export change (model)	Export values (GTAP)	Elasticity of substitution (GTAP)
Electron	0.6	-2.8	0.2	0.2	0.3	74798.7	8.8
Apparel	0.9	8.9	2.1	0.9	9.2	69587.1	7.4
ElecMach	0.7	-2.1	0.5	0.3	1.5	53484.2	8.1
Instrumnt	0.7	-2.1	0.5	0.3	1.3	53484.2	8.1
Textiles	1.0	5.5	1.7	0.9	6.4	39431.7	7.5
SocActProc	0.9	-2.2	0.6	0.4	1.6	39173.8	7.5
OthManuf	0.9	-2.2	0.6	0.5	0.7	39173.8	7.5
Leather	1.1	7.2	2.0	0.7	10.5	30420.6	8.1
Chemical	0.8	-0.1	0.7	0.6	0.8	22775.9	6.6
Medicine	0.8	-0.1	0.7	0.6	1.0	22775.9	6.6
ChemFibre	0.8	-0.1	0.7	0.3	3.1	22775.9	6.6
RubPlast	0.8	-0.1	0.7	0.4	2.5	22775.9	6.6
Transport	0.9	-2.3	0.3	0.3	-0.3	13476.4	3.8
Furniture	0.8	-2.8	0.4	0.4	0.1	11505.9	6.8
MetalProd	0.8	1.2	0.9	0.6	2.3	10991.9	7.5
BuildMat	0.8	2.6	1.3	0.9	2.3	7983.8	5.8
Commerce	0.9	-2.5	0.3	0.4	-0.5	7792.5	3.8
FoodProc	1.5	-0.5	1.4	1.0	2.3	7766.2	5.6
OthTrEq	0.7	-0.9	0.6	0.3	2.8	5351.4	8.6
SocServ	0.9	-2.4	0.2	0.3	-0.3	5156.0	3.8
OthCROP	1.6	14.7	4.5	2.9	7.5	4033.6	4.9
PapPrint	0.9	-2.9	0.4	0.4	-0.1	3112.6	5.9
NonFreOre	0.7	-2.2	0.4	0.6	-1.0	3041.3	8.4
NFerProd	0.7	-2.2	0.4	0.4	-0.2	3041.3	8.4
FreOreMin	0.8	-1.3	0.5	0.5	0.0	2942.2	5.9
IronSteel	0.8	-1.3	0.5	0.3	1.0	2942.2	5.9
CrudeOil	0.1	-0.5	0.1	0.1	-0.4	2739.7	14.9
Machinery	0.7	-6.8	-0.6	0.1	-3.3	2671.2	5.6
SpecEquip	0.7	-6.8	-0.6	0.0	-3.3	2671.2	5.6
AutoMobile	0.7	-6.8	-0.6	0.0	-2.9	2671.2	5.6
EduSciHel	0.9	-2.4	0.2	0.4	-0.6	2249.0	3.8
PubAdmin	0.9	-2.4	0.2	0.4	-0.6	2249.0	3.8
OthLstk	1.8	-1.3	1.3	1.1	0.7	1528.2	3.1
RefPet	0.4	0.2	0.4	0.3	0.4	1264.3	4.2
CoalMin	0.6	0.8	0.7	0.7	0.3	1250.8	6.1
Quarrying	0.5	0.1	0.6	0.5	0.3	1033.9	1.8
Beverage	1.2	2.1	2.1	1.0	2.6	961.9	2.3
Tobacco	1.2	2.1	2.1	1.0	2.6	961.9	2.3
Finance	0.8	-2.3	0.2	0.3	-0.4	886.0	3.8
Corn	2.0	21.1	9.7	4.5	13.7	721.9	2.6
Construc	0.8	-2.6	0.1	0.3	-0.5	690.5	3.8
GRAINFrg	1.4	52.9	10.1	4.6	30.1	568.5	5.2
FISHING	1.2	2.9	2.4	1.3	2.6	504.6	2.5
Telecomm	0.8	-2.2	0.2	0.2	0.0	482.2	3.8
Util	0.7	-1.4	0.5	0.4	0.2	290.7	5.6
Wool	2.2	-7.1	1.6	1.1	6.7	210.5	12.9

Sector	Price change (GTAP)	Export change (GTAP)	Demand shift (GTAP)	Price change (model)	Export change (model)	Export values (GTAP)	Elasticity of substitution (GTAP)
VgtOil	1.7	-9.2	0.2	0.8	-3.7	190.5	6.6
FORESTRY	0.7	-1.4	0.4	0.7	-1.3	102.6	5.0
Cotton	1.8	28.6	7.0	4.4	13.2	88.5	5.0
OTHAG	1.8	28.6	7.0	4.2	14.0	88.5	5.0
Wheat	1.4	6.8	2.1	0.0	-	48.3	8.9
Rice	2.1	452.5	20.9	15.3	61.5	42.5	10.1
SUGAR	1.4	24.8	5.6	1.5	24.2	27.6	5.4