International Trade and CGE Models: Theory, Practice, Problems, Improvements

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CGE/Trade Modeling Issues

- The specification of goods as tradable, nontradable, traded, and non-traded.
  - The Armington specification in CGE models: degrees of “tradability”
  - Links between commodity and factor markets
- The role of the exchange rate
  - Real versus “financial” exchange rates
- Trade links to economic performance

Issues: Structural Adjustment

- Three kinds of shocks
  - Changes in world prices (e.g. oil prices)
  - Changes in trade balances (e.g., financial crisis)
  - Differential domestic and foreign inflation
- Adjustments
  - Absorption: magnitude and macro composition
  - Structure of production and trade
  - Changes in the exchange rate

Macroeconomic Adjustment

GDP = C + I + G + E - M

GDP + (M – E) = C + I + G

production + trade balance = absorption

Trade shocks and structural adjustment:

“Expenditure reduction” versus

“Expenditure switching”

Modeling Issues

- The specification of goods as tradable, nontradable, traded, and nontraded
  - The Armington specification in CGE models
  - Theoretical properties of this model compared to "standard" trade theory
- The role of the exchange rate in CGE models
  - Real versus "financial" exchange rate

The Equilibrium Exchange Rate

- Macro “shocks” emanating from world markets require adjustment in the exchange rate.
- Financial versus real exchange rates
  - R as a signal in asset markets
    - Affects returns on portfolio investment
  - R as a signal in product markets
    - Affects relative product prices

Purchasing Power Parity: PPP Exchange Rate

$$R^r = R\frac{\pi}{P}$$

$$\hat{R}^r = \hat{R} + \left(\hat{\pi} - \hat{P}\right)$$

$$\hat{R}^r = 0 \Rightarrow \hat{R} = \hat{P} - \hat{\pi}$$

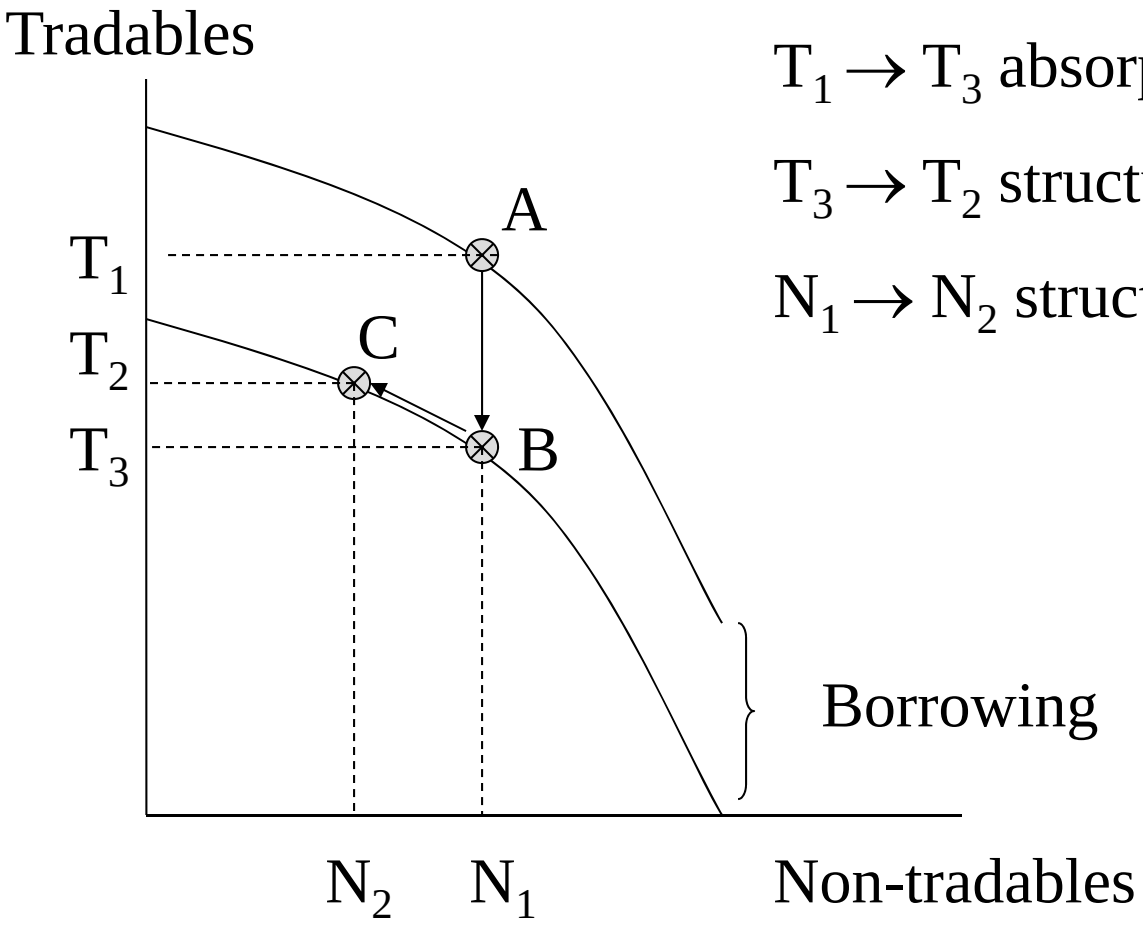
PPP Exchange Rate

- Units
  - R has units of domestic currency per $US.
  - R↑ is a depreciation of the exchange rate.
- Focus on “real” exchange rate
  - Impact on relative prices in commodity markets

Problems

- If all goods are tradable, then PPP is trivial. All prices set by world prices
  - Law of One Price
- PPP must measure relative prices of tradables and nontradables.
  - Harberger, Edwards, Srinivasan.
- Underlying Salter-Swan model.

Salter-Swan Model



$T_1 \rightarrow T_3$ absorption cut

$T_3 \rightarrow T_2$ structural adjustment

$N_1 \rightarrow N_2$ structural adjustment

Problems

- Salter-Swan raises issues of the role of non-traded goods in models of international trade
  - Non-traded commodities
  - Role and definition of the “real” exchange rate
- Role of the “law of one price” in trade theory

Law of One Price

- Given commodity arbitrage, all traded goods will have the same price in all markets
- Very powerful assumption in neoclassical trade theory
  - Project analysis
  - Theory of comparative advantage
  - Major theorems: Stolper-Samuelson, Rybcznski, Factor-Price Equalization

Law of One Price

1. All domestic prices of tradables are set by world prices. All traded goods are the "same" (perfect substitutes).
2. Any change in the price of an import is immediately transmitted to price of the corresponding domestic good.
3. Tariff policy is very powerful. Immediately affects price of domestically produced goods.

Law of One Price

4. Should observe extreme specialization in production.
5. Should never observe two-way trade (cross hauling).
6. Trade shares are not important. Only tradability matters.

Law of One Price

7. Stolper-Samuelson: Strong (magnified) links between changes in world prices and changes in factor prices
8. Rybczynski: Strong (magnified) links between changes in endowments and changes in the structure of production and trade, with no changes in factor prices

Problems

- Implications of Law of One Price are all false empirically
- Changes in world prices and tariffs are only weakly transmitted to domestic markets
- Do not observe extreme specialization
- Observe two-way trade in most sectors, and at very fine levels of disaggregation

Problems

- Trade shares are clearly important
  - Sectors with large trade shares are more affected by changes in world markets
- Do not observe strong links implied by Stolper-Samuelson and Rybcznski Theorems
  - Weak links between world prices and wages
  - Endowment changes have strong effects on factor returns

Nontradable Goods

- Introduce nontradable goods into the model
  - Goods which (for various reasons) are only sold in the domestic market. No international trade.
- Long history in international trade theory
  - This specification “qualifies” the major theorems of international trade
  - Theoretical and empirical question: How much qualification?

Problems

- Hard to define tradables and nontradables empirically
  - Most sectors have some trade (often exports and imports) at very fine levels of disaggregation
  - Nontraded goods are a very small share of GDP
- Requires dichotomous classification of goods: purely tradable or nontradable

Armington Insight

- Paul Armington: specified imported goods as imperfect substitutes (CES) for domestic goods with the same sector classification
  - Allow degrees of "tradability" rather than dichotomous classification
    - Originally for estimating import demand functions
- Term "Armington model" now denotes model with imperfect substitutability of either/both exports and imports for domestic goods

The 1-2-3 Model: Tradability in Commodity Markets

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1-2-3 Model

- Questions regarding the theoretical properties and validity of the Armington trade model
  - How does it relate to “standard” trade theory
- Links between “macro” and “structural” models of adjustment
  - Role of relative prices and the exchange rate

1-2-3 Model

- 1 country, 2 activities, 3 commodities
- 2 activities, producing D and E.
  - E not consumed domestically.
- Additional commodity, M, consumed domestically but not produced.

1-2-3 Model

- Aggregate GDP (X) is fixed
  - Full employment model
- Trade balance set exogenously
- World prices of M and E are fixed (pwm, pwe)
- Total absorption (Q) is endogenous

1-2-3 Model

$$(1) \quad \overline{X} = G(D, E; \Omega)$$

$$(2) \quad Q = F(D, M; \sigma)$$

1-2-3 Model

$$(3) \quad \frac{E}{D} = k_2 \left(\frac{P^e}{P^d} \right)^{\Omega}$$

$$(4) \quad \frac{M}{D} = k_1 \left(\frac{P^d}{P^m} \right)^{\sigma}$$

1-2-3 Model

$$(5) \quad P^m = R \cdot \pi^m$$

$$(6) \quad P^e = R \cdot \pi^e$$

$$(7) \quad \pi^m \cdot M = \lambda \cdot \pi^e \cdot E$$

Equilibrium Domestic Price

$$\hat{P}^d = \frac{1}{(\sigma+\Omega)}\left[(\sigma-1)\cdot\hat{\pi}^m + (1+\Omega)\cdot\hat{\pi}^e + \hat{\lambda}\right]$$

$$R \equiv 1 \Rightarrow \hat{R} = 0$$

Exchange rate is the numeraire

Fixed World Prices, Change in λ

Case 3: $\hat{\pi}^m = \hat{\pi}^e = 0, \quad \hat{\lambda} > 0$

Implies: $\hat{P}^d > 0$

real appreciation

"Dutch disease" case.

Change in World Prices, Fixed λ

Case 4: $\hat{\lambda} = 0, \quad \hat{\pi}^m > 0, \quad \hat{\pi}^e = 0$

If $\sigma < 1 \Rightarrow \hat{P}^d < 0$ (depreciation)

If $\sigma > 1 \Rightarrow \hat{P}^d > 0$ (appreciation)

and trade volume falls.

Equilibrium PLD EXR

$$\hat{R} - \hat{P}^d =$$ PLD exchange rate

$$-\frac{\left(\sigma \cdot \hat{\pi}^m + \Omega \hat{\pi}^e\right)}{\sigma + \Omega}$$ world inflation

$$+\frac{\left(\hat{\pi}^m - \hat{\pi}^e\right)}{\sigma + \Omega}$$ terms of trade

$$-\frac{\hat{\lambda}}{\sigma + \Omega}$$ trade balance

1-2-3 Model: Conclusions

- Addresses all the weaknesses of the “law of one price” in empirical models
  - Weaker, more realistic, links between world prices, price wedges, and domestic markets
  - Trade shares matter empirically as much as elasticities
  - No tendency toward extreme specialization
  - Two-way trade is allowed

1-2-3 Model: Conclusions

- Explicit introduction of the real exchange rate in the 1-2-3 model widens the applicability of the CGE model framework
  - Introduction of trade-balance constraint
  - Real exchange rate as a relative price, NOT a "financial" variable
  - Widely used in analysis of structural adjustment
- Generalization of the Salter-Swan model

1-2-3 Model: Conclusions

- "Standard" trade model is a special limiting case of the 1-2-3 model, as CES and CET elasticities move to infinity
  - Allows complements as well as substitutes in degrees of "tradability"
- Strong theoretical underpinning for trade-focused CGE models
  - Now need to consider factor markets

Links Between Commodity and Factor Markets: Stolper-Samuelson and Rybcznski Theorems in the 1-2-2-3 Model

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1-2-2-3 Model

- 1 country, 2 activities, 2 factors, 3 commodities
- Two activities: Exports (E) and Domestic goods (D)
  - No CET function to determine exports
- Two factors of production: Labor (L) and capital (K).
  - E is capital intensive, D is labor intensive
  - Introduce factor markets and assume full employment
- Three goods: E, D, and M (imports). E is exported, not consumed domestically; M and D are imperfect substitutes in consumption.

1-2-2-3 Model

- Extend Jones (1974):
  - imperfect substitution between traded and non-traded goods: Armington and 1-2-3 model
  - include the links between product markets and factor markets: Jones algebra
- Include the balance of trade and the real exchange rate in the model: from 1-2-3 model
  - Trade balance can affect factor markets
- This model underlies all trade-focused CGE models

1-2-2-3 Model

- Analytic relations
  - Contract curve: movements along the PPF
    - Replaces the CET function to determine exports
  - Export supply function: Implicit, no CET function
  - Import demand function: same as 1-2-3 model
  - Trade balance constraint: same as 1-2-3 model
- Can solve the model analytically

1-2-2-3 Model

- Changes in equilibrium relative wages can be decomposed analytically into effects arising from changes in:
  - relative world prices (Stolper-Samuelson)
  - the trade balance
  - relative factor supplies (Rybcznski)
- Can show that the HOS model is a special case of the 1-2-2-3 model

Wage Equation

$$\left(\hat{W}_K - \hat{W}_L\right) = \frac{1}{|\theta|\left(\sigma_Q + \Omega\right)}[$$

$$+\left(\sigma_Q - 1\right)\left(\hat{P}^E - \hat{P}^M\right)$$ Price effect

$$-\hat{\Phi}$$ Trade balance effect

$$+\frac{1}{|\lambda|}\left(\hat{L} - \hat{K}\right)]$$ Factor endowment effect

Stolper-Samuelson Theorem

With no change in factor supplies, the equation is given below. The magnification effect is reduced. When σ = 1, wages are independent of prices. When σ < 1, the sign is negative, the opposite from the HOS model.

$$\left(\hat{W}_K - \hat{W}_L\right) = \frac{1}{|\theta|}\left[\frac{\left(\sigma_Q - 1\right)}{\left(\sigma_Q + \Omega\right)}\right]\left(\hat{P}^E - \hat{P}^M\right)$$

Rybczynski Theorem

With only a change in factor endowments, changes in production are given below. The magnification effect is weakened compared to the HOS model.

$$\left(\hat{E} - \hat{D}\right) = \frac{1}{|\lambda|}\left[\frac{\sigma_Q}{\left(\sigma_Q + \Omega\right)}\right]\left(\hat{K} - \hat{L}\right)$$

1-2-2-3 Model: Analytic Results

- Stolper-Samuelson Theorem
  - Sign depends on Armington elasticity
  - Magnification effect greatly weakened
- Rybczynski Theorem
  - Magnification effect greatly weakened
  - Wages change with changes in factor supplies
- Trade balance changes affect wages
  - Sign opposite from that of labor economists

1-2-2-3 Model: Empirical Results

- Increase in world price of capital intensive export increases return to capital
  - Weakened Stolper-Samuelson result.
- Increase in the trade deficit reduces the gap between skilled and unskilled wages
  - Opposite to prediction from factor content analysis.
- Increase in the supply of labor reduces the relative return to labor
  - Qualifies Rybczynski Theorem: Factor supplies matter

1-2-2-3 Model: Conclusions

- "Standard" theoretical trade model is a special case of the 1-2-2-3 model
- Addition of "tradability" yields a much more realistic model of links between commodity and factor markets
  - Links between factor markets and trade balance
- Core theory underlying CGE models

Limitations and Extensions of "Armington" Models

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Problems: Welfare Analysis

- Both single-country and global CGE models capture the welfare impacts of "distorting" policies (e.g., tariffs, taxes, QRs, etc.)
  - Welfare impact of removing all distortions is always positive, as expected from theory
- However, magnitude of welfare gains from trade liberalization in CGE models is disappointing—much less than expected

Problems: Welfare Analysis

- Case studies indicate much greater welfare gains from pursuing an “open” development strategy and trade liberalization
- Harberger theorem on welfare analysis: “triangles are smaller than rectangles”
  - Robinson-Thierfelder article on trade theory: “The Search for Large Numbers”
  - Rectangles: TFP-trade links

Problems with Armington Models

- The Armington model has done very well for a variety of purposes
  - e.g., structural adjustment, trade reform
- We are now moving to long-run analysis
  - e.g., climate change, long-run growth and structural change
- Problems with the Armington model are constraining analysis

Problems: Single Country Models

- Use of homothetic CES/CET functions
  - Unitary “expenditure” elasticity of exports and imports wrt to changes in income
    - Trade grows roughly proportionately with GDP growth
    - “Only” changes in relative prices change trade shares
  - Inconsistent with empirical analysis showing dramatic increases in trade shares over time
    - Not driven by changes in prices

Problems: Single Country Models

- "Small country" assumption
  - Single-country Armington CGE models also often assume fixed world prices
    - Theoretically inconsistent with Armington assumption of imperfect substitutability
  - Spain may be "small" in world leather market, but it is "large" in world market for Spanish leather
    - With Armington, every country should face a downward sloping demand curve for its exports

Problems: Global Models

- Downward sloping demand curves for exports allows possibility of exploiting market power
  - Imperfect competition model: implicit argument for an “optimal tariff”
  - Possibility of “trade wars” in global models
- Armington: Incomplete/inadequate model of trade expansion and market penetration
  - Only relative prices matter

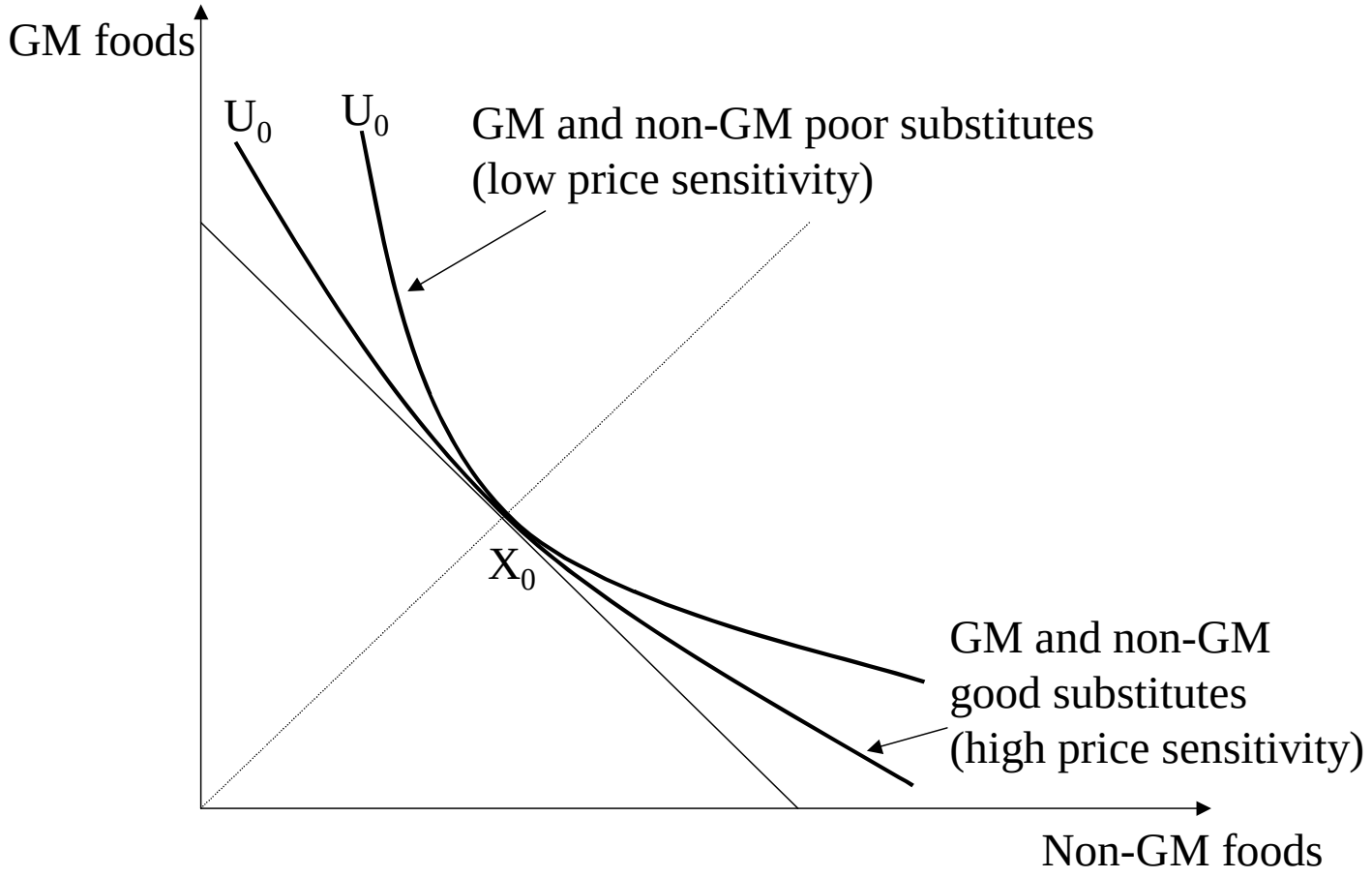
Problems: Global Models

- If a country grows relative to other countries, it will always have a terms-of-trade loss
  - Exports grow with GDP, but meet downward sloping import demand functions from partners
  - Increased import demand meets upward sloping export supply functions from partners
- Homotheticity: model world trade grows roughly with world GDP. Very unrealistic.

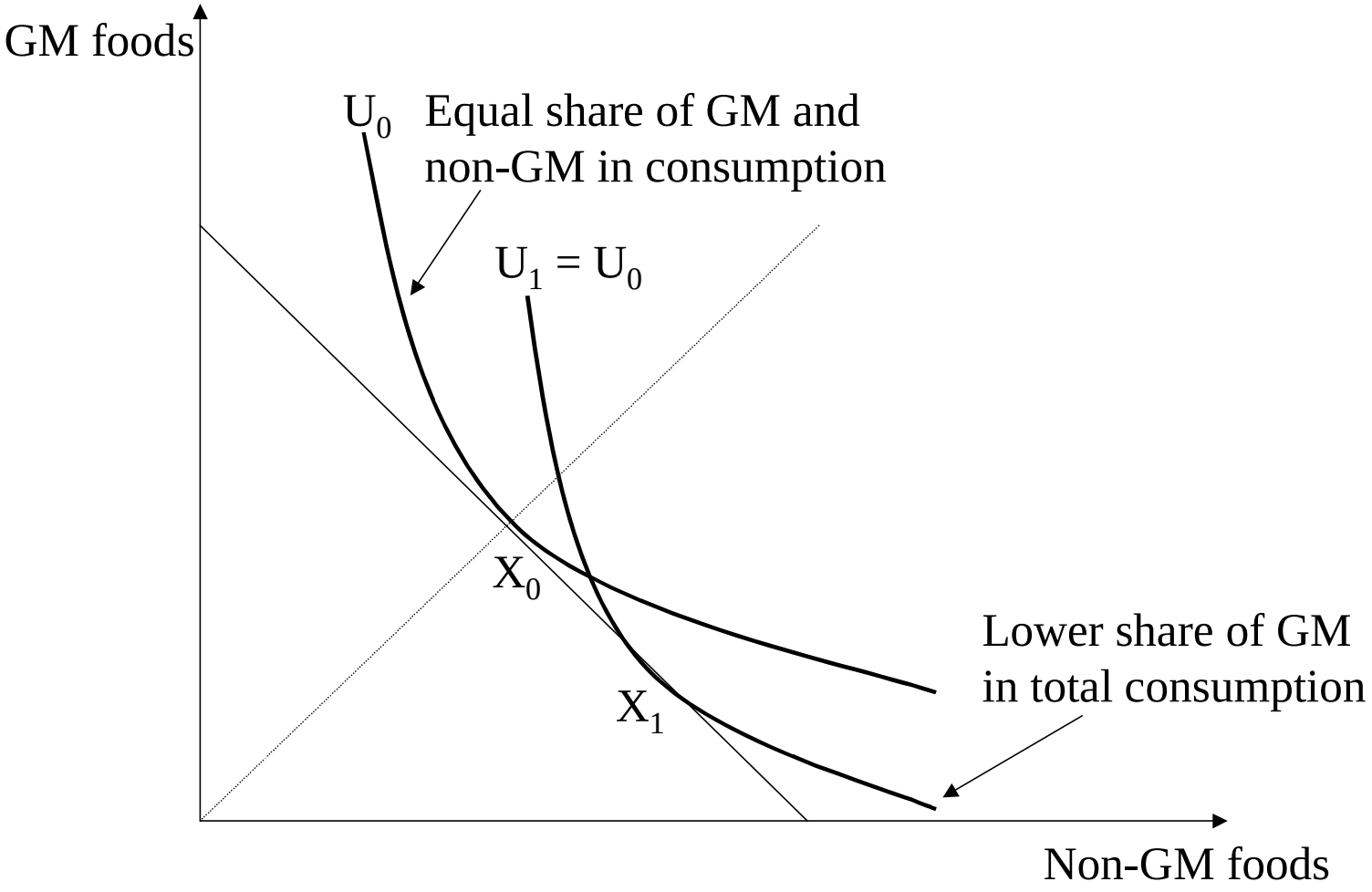
Extensions to Armington Model

- Functional form: move beyond CES/CET to include functions that allow income effects
  - Translog
  - Exogenous “shifts” in CES/CET functions
  - Nielson, Robinson, Thierfelder (GMOs)
- Empirical validitation, but no advance in the underlying theory

Consumer Preferences: Different Degrees of Price Sensitivity



Consumer Preferences: Structural Change



Extensions to Armington Model

- CES/CET Armington model is a “shallow” structural model
  - No explanation of origin of elasticities or how they might change over time
- Time to develop “deeper” structural models of exporting and importing, and integrate them into CGE models

Exports

- Micro analysis of firm behavior
  - Export-linked productivity growth at the level of activities
  - Melitz market model: Firm heterogeneity and exports
- Implementation: representative firms versus microsimulation of producers

Imports

- Representative consumers:
  - Shifts in “taste” for imports: empirical estimation
- Production technology: trade and TFP
  - Imported inputs and technology transfer
- Value chains
  - Import content of exports
  - Processing zones versus broader value chains

Conclusion

- Armington model was a major theoretical and empirical advance in trade modeling
- Limitations of the model are becoming apparent and limiting, especially for analysis of long-run growth and structural change
- New theoretical/empirical work is underway
  - Value chains
  - Trade/productivity links

Conclusion

- Need to incorporate new theoretical and empirical work into CGE trade models
  - Work underway (e.g., Melitz model)
- Need for better links between theoretical and empirical work program
  - Powerful ability to simulate theoretical models
  - Need for parameter estimation and validation