Modern trade theory for CGE modellers: the Armington, Krugman and Melitz models

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Introduction

- **Derive the Armington, Krugman and Melitz models of trade as special cases of a general model.**
- **Examine optimality properties of Melitz**
- **Look at the Balistreri-Rutherford decomposition algorithm for solving Melitz general equilibrium model**
- **Set up numerical Melitz model**
- **Demonstrate that Melitz welfare results can be decomposed into Armington effects**
- **Show that Melitz results look like Armington results with a high substitution elasticity**
- **Show how a working Armington model (e.g. GTAP) can be converted into a Melitz model**

General model

Agents in country d choose their inputs of widgets from firm k in country s to minimize the cost of satisfying their total widget requirements, specified as a CES aggregate over all k and s with substitution elasticity σ.

Widget firms in each country are monopolistically competitive.

Each firm in country s incurs a fixed setup cost, H_s.

For a firm in s to export to d, it must incur a further fixed setup cost, $F_{s,d}$.

Each firm k in s has its own exogenously given level of marginal productivity, $\Phi_{k,s}$.

Deriving Armington, Krugman and Melitz from the general model

	Armington	Krugman	Melitz
Assumptions			
Perceived demand elasticity by firms	$-\infty$	$-\sigma$	$-\sigma$
Fixed setup cost for a firm in s, H_s	0	+	+
Fixed trade cost for a firm on s,d link, $F_{s,d}$	0	0	+
Marginal productivity of firm k in s, $\Phi_{k,s}$	same for all k in s	same for all k in s	Pareto over k in s
Implications			
Number of firms in s	exogenous	endogenous	endogenous
Fraction of s firms that export to d	1	1	endogenous
Industry productivity	exogenous	endogenous	endogenous
Fixed inputs per unit of output	0	endogenous	endogenous
Variable inputs per unit of output	exogenous	exogenous	endogenous
Number of varieties available in d	exogenous	endogenous	endogenous
Welfare effects of tariff changes arise from endogenous changes in:			
Terms of trade	yes	yes	yes
Efficiency (triangles)	yes	yes	yes
Love of variety	no	yes	yes
Industry productivity	no	yes	yes
Fixed inputs per unit of output	no	yes	yes
Variable inputs per unit of output	no	no	yes

Optimality in the Melitz model

Do Melitz assumptions provide an argument for policy intervention?

World-wide planner chooses outputs from each firm k in each country s and trade flows on each s,d link to minimize the cost of satisfying widget requirements in each country. The planner's solution turns out to be the Melitz market solution under free trade. This result is a generalization of Dixit & Stiglitz, 1976.

Conclusions:

1. **Despite deviations from pure competition, Melitz does not support intervention**
2. **Envelope theorems will be useful in result interpretation**
3. **Intuition based on all encompassing agent is OK**
4. **Planner problem could provide an alternative computational approach**

Balistreri-Rutherford decomposition algorithm for solving GE models with Melitz industries

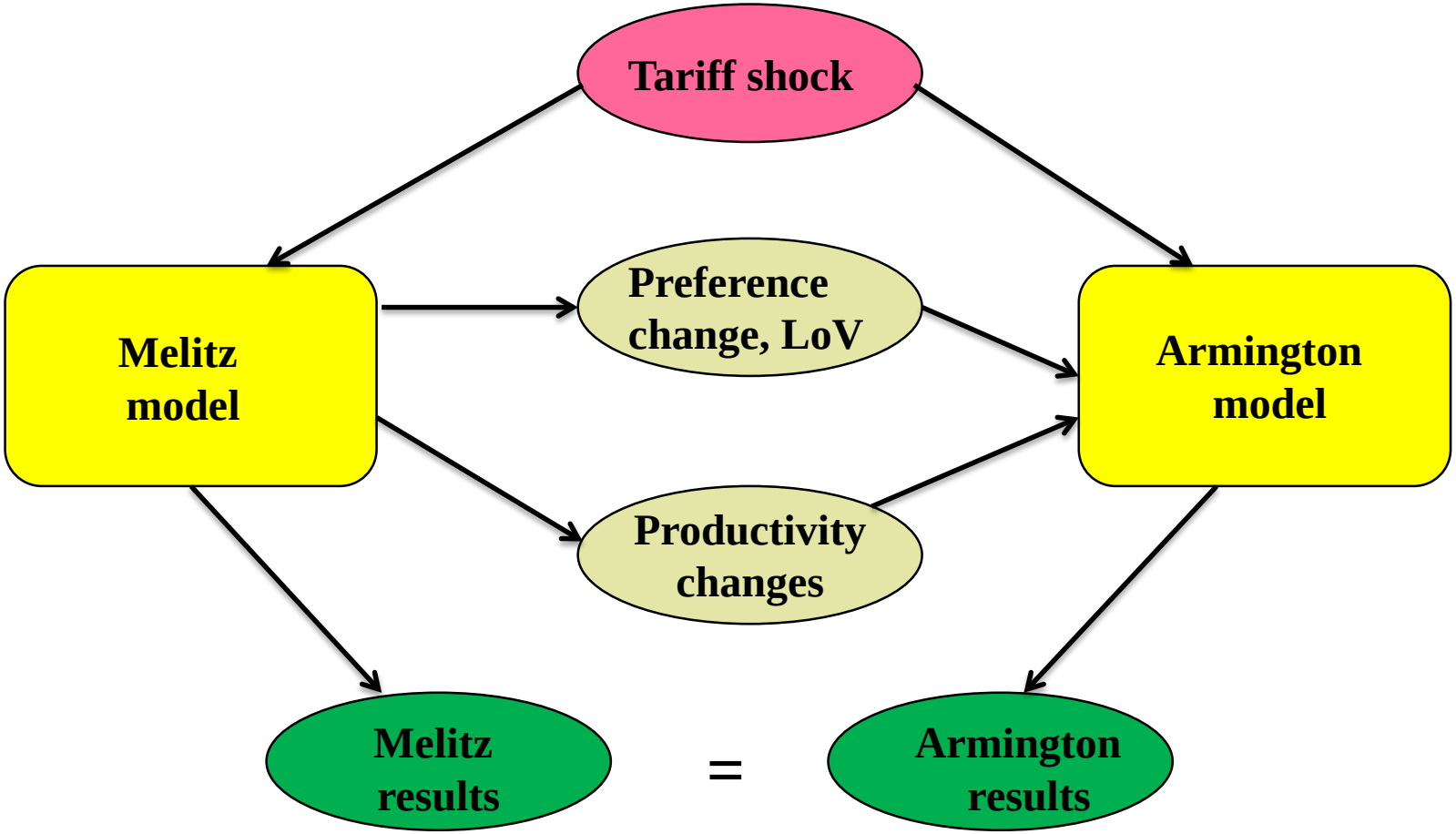
B&R start by solving a world industry model for each Melitz commodity based on *guesses* of wage rates and demands in each country.

Industry models generate estimates of industry productivity and preference shifts (reflecting numbers of varieties or firms) which are transferred into an Armington multi-industry general equilibrium model.

The Armington model is solved to generate estimates of wage rates and demands for commodities which are fed back into the Melitz industry models.

A full solution of the general equilibrium model with Melitz industries is obtained when wage rates and demand variables emerging from the Armington model *coincide* with those which were used in the Melitz industry models.

Melitz = Armington with extra shocks



Melitz results can be decomposed into

- **Traditional Armington effects (efficiency triangles and terms of trade)**
- **Industry productivity effects (firm heterogeneity & economies of scale)**
- **Preference effects (love of variety)**

all calculated from an Armington model

Two-country Melitz model: effects of tariffs imposed by country 2

Rate of country 2's tariff on country 1	7%		13%	
	Country 1	Country 2	Country 1	Country 2
Welfare decomposition				
Welfare (%)	-0.82	0.59	-1.44	0.73
made up of contributions from changes in:				
Efficiency triangles	0.00	-0.16	0.00	-0.50
Terms of trade	-0.82	0.80	-1.42	1.37
Industry productivity	-3.33	-2.79	-5.89	-5.02
Preferences (love of variety)	3.33	2.75	5.88	4.87

Productivity and preference effects approximately offset.
Why?

Why do productivity and variety effects cancel out?

- **With tariffs at zero, Melitz generates an optimal trade-off between keeping costs down through long production runs in low-marginal cost firms and meeting consumer demand for variety.**
- **Tariffs change the cost/variety trade-off in each country.**
- **But the envelope theorem suggests that marginal changes in this trade-off away from the optimum have little effect on welfare. Thus, productivity and variety effects must approximately cancel.**
- **In both countries, trade restriction causes reduced productivity (higher costs) offset by increased varieties. A relatively large number of small, domestic-only, low-productivity firms replace imports from a relatively small number of high-productivity foreign firms.**
- **The cancelling out of the variety and productivity effects leaves welfare in our Melitz tariff simulations determined by factors that have been familiar since the 1950s (e. g. Corden, 1957 & Johnson, 1960): terms-of-trade and efficiency.**

Comparing Armington and Melitz:
effects of tariffs imposed by country 2

If the extra Melitz effects (productivity and love of variety) cancel out, how is it that Balistreri & Rutherford (2013) find that Melitz gives considerably different welfare effects than Armington with a similar database?

In making a Melitz/Armington comparison, we should calibrate the substitution elasticities so that the two models produce comparable changes in trade volumes.

	Melitz with variety elasticity at 3.8		Armington with dom/imp elast. at 3.8		Armington with dom/imp elast. at 8.45	
Rate of country 2's tariff on country 1	13%		13%		13%	
	Country 1	Country 2	Country 1	Country 2	Country 1	Country 2
Volume of exports	-32	-36	-14	-20	-32	-36
Volume of imports	-36	-32	-20	-14	-36	-32
Welfare (%)	-1.44	0.73	-1.62	1.36	-1.38	0.86

An inter-variety elasticity in Melitz of 3.8 is equivalent to an inter-country elasticity in Armington of 8.45.

Theory literature: Same trade effects → same welfare effects (Arkolakis et al., 2012)

Converting an Armington global model (e.g. GTAP) into a Melitz model requires 3 steps

Step 1:

Allow for productivity effects by adding equations to endogenize technical change in industries that produce Melitz goods

Additional all-input-using technical change in the c-producing industry in country s

$$\mathbf{aind(s,c)} = \left(\frac{1}{\sigma_c}\right) * \mathbf{xind(s,c)} - \frac{1}{\sigma_c} * \mathbf{tfc(s,c)} + \left(\frac{\sigma_c - 1}{\sigma_c}\right) * \sum_d \phi_{sd,c} * \mathbf{R(s,d,c)} \qquad \mathbf{(1)}$$

economies of scale	total fixed costs for industry	marginal productivity effects (change in composition of firms on s,d link)

Converting an Armington global model (e.g. GTAP) into a Melitz model requires 3 steps

Step 2:

Allow for love of variety by adding equations to endogenize technical change in industries that mix varieties to create composite Melitz goods

Technical change in the mixing industry for commodity c in country d (s-saving technical change)

Number of varieties of c sent from s to d

$$a_{sd,c}^{mix} = \frac{n_{sd,c}}{(\sigma_c - 1)} \qquad (2)$$

Converting an Armington global model (e.g. GTAP) into a Melitz model requires 3 steps

Step 3:

Add Melitz equations for tfc(s,c), $\phi_{sd,c}$, $n_{sd,c}$, and $n_{s,c}$ to tie up loose ends introduced in steps 1 and 2

Fixed costs in c-producing industry in country s

$$FC(s,c) * tfc(s,c) = N_{s,c} * H(s,c) * n_{s,c} + \sum_{d} N_{sd,c} * F_{sd,c} * n_{sd,c} \quad (3)$$

Average of the marginal productivities of c-producing firms that operate on the s,d link

$$\phi_{sd,c} = x(c,s,d) - n_{sd,c} \quad (4)$$

Number of firms in country s that can operate on the s,d link

$$n_{sd,c} = n_{c,s} - \alpha * \phi_{sd,c} \quad (5)$$

Determines the price of domestic and imported goods used by the mixing industries

$$p_{sd,c} = p_{input}(s,c) - \phi_{sd,c} + t_{sd,c} \quad (6)$$

Zero pure profits in mixing industries

$$p_{input}(s,c) + q_{input}(s,c) = \sum_{d} V(s,d,c) * \left(p_{sd,c} + x(s,d,c) - t_{sd,c} \right) \quad (7)$$

Concluding remarks

Armington is a special case of Krugman
Krugman is a special case of Melitz, and
Melitz is a special cases of a more general model

Despite increasing returns to scale, imperfect competition, separate variety for each firm, and different marginal productivity levels across firms, the Melitz model produces optimal intra-industry outcomes.

-- envelope theorems work

Melitz solutions can be calculated in an Armington model with extra shocks to industry productivity and preferences.

Concluding remarks

Melitz welfare results can be decomposed into

- **efficiency and terms of trade effects**
- **industry productivity effects**
- **preference effects**

all calculated in an Armington model.

Productivity and preference effects offset - envelope theorem

Melitz results can be reproduced in an Armington model with a high Armington elasticity

Armington can be converted into Melitz by adding equations for tech changes in Melitz and mixing industries