Incorporating Melitz into WiNDC

27th Annual Conference on Global Economic Analysis

Alan K. Fox

June 6, 2024

Motivation

- The Melitz model of heterogeneous firms in production (2003) has provided new insights into the behavior of international trade and production.
- While the model is relatively parsimonious, its incorporation into common CGE modeling frameworks has been relatively slow due to technical difficulties.
- This project aims to extend the canonical WiNDC model to include Melitz-style production , following the work of Balistreri and Tarr (2022a,b).

Two roads to Melitz

- Balistreri and Tarr (GAMS)
  - "Mathematics of generalized versions of the Melitz, Krugman and Armington models with detailed derivations," *Journal of Global Economic Analysis*, 2022a, 7(2). https://doi.org/10.21642/JGEA.070203AF.
  - "Welfare gains in the Armington, Krugman and Melitz models: comparisons grounded on gravity," *Economic Inquiry*, 2022b, 60 (4), 1681–1703. https://doi.org/10.1111/ecin.13082.
- Dixon, Jerie and Rimmer (GEMPACK)
  - "Melitz in GTAP made easy: the A2M conversion method and result interpretation," *Journal of Global Economic Analysis*, 2019, 4(1). https://doi.org/10.21642/JGEA.040104AF.

Motivation for using Melitz approach

- When reducing trade costs, the Armington approach only offers welfare gains from the increase in factor productivity.
- Melitz, like Krugman, also yields *love of variety* gains.
- Melitz additionally yields gains through *the selection effect*.
- Under Melitz, relatively efficient firms earn additional profits from exporting. This in turn induces new firm entry and the exit of relatively inefficient firms.
- Balistreri and Tarr (*Econ. Inq.* 2022) find that love of variety is responsible for most of the welfare increase over Armington, but the selection effect does play a part in raising welfare gains.

Features of Balistreri and Tarr's implementation

- Code is written in GAMS—the same language as WiNDC
- In style of Melitz
  - Firm productivity, prices and quantities are continuous variables
  - Fixed cost of entry paid before revelation of firm productivity
  - Fixed cost of selling in each market
  - Free entry condition: $E(\pi) = 0$ in steady state with a death rate of firms
- Additional features
  - Labor-leisure choice is available
  - Sector-specific factors available, which can range [0,1] by sector
  - No labor-leisure, no specific factors are special cases of the general model

WiNDC: **Wi**sconsin **N**ational **D**ata **C**onsortium

- Open-source subnational datasets for economic analysis
- Latest release: 4.0.0, October 2023
- Core buildstream: 1997—2021, 50 states + DC, 71 sectors
- Household buildstream: 5 household types covering 2015—2021
  - Can use Current Population Survey (Census) or Statistics of Income (IRS)
- GTAP-WiNDC buildstream (works with GTAP versions 9 and 11)
  - Default year 2017, works with 2011 and 2014 (2004 & 2007 w/code mods)
  - Sectors: 10, 32 (1 ag) or 43 (12 ag) standard, but aggregation is flexible
  - 5 household types carry through

Model and Data

- WiNDC 4.0 is the starting point for our modeling and build stream.
- GTAP version 11c (base year 2017)
- Regions:
  - North America
  - Europe
  - Asia
  - Rest of World
- NOTE: Breaking out the United States and individual states will come later.

Model Sectors: windc_10 aggregation

ele	Armington	Utilities (electricity-gas-water)
ogs	Armington	Crude oil and natural gas
col	Armington	Coal
oil	Armington	Petroleum, coal products
eis	**Melitz**	**Energy-intensive manufactures**
trn	Armington	Transportation
agr	Armington	Agriculture forestry and fishing
man	**Melitz**	**Other manufactured products**
cns	Armington	Construction
ser	Armington	Other public and private services

Implementation: new variables

- N_{mrs} No. of Melitz firms in sector m ∈ M, reg r, selling in region s
- $\tilde{p}_{mrs}$ Gross firm-level price of Melitz representative firms in sector m ∈ M from region r selling in region s; includes firm markup, tariffs, and iceberg costs.
- q_{mrs} Firm-level qty of Melitz representative firms in sector m ∈ M from region r selling in region s.
- $\tilde{\phi}_{mrs}$ Firm-level productivity of Melitz representative firms in sector m ∈ M from region r selling in region s.

Melitz-specific equations

4. Melitz Specific Equations			
M.8 Dixit-Stiglitz price index (3.54)	$P_{ms} = \left[\sum_{r \in R} \lambda^M_{mrs} N_{mrs} \tilde{p}^{1-\sigma^M}_{mrs}\right]^{1/(1-\sigma^M)}$	Q_{ms} $\forall\, s \in R$ and $m \in M$	$R \times M$
M.9 Market clearance for composite input (3.85)	$y0_{mr} Y_{mr} = \delta f^E_{mr} n_{mr} + \sum_{s \in R} N_{mrs} \left(f^M_{mrs} + \frac{\tau_{mrs} \tilde{q}_{mrs}}{\tilde{\varphi}_{mrs}}\right)$	c_{mr} $\forall\, r \in R$ and $m \in M$	$R \times M$
M.10 Firm-level demand (3.55)	$\tilde{q}_{mrs} = \lambda^M_{mrs} q0_{ms} Q_{ms} \left(\frac{P_{ms}}{\tilde{p}_{mrs}}\right)^{\sigma^M}$	$\tilde{p}_{mrs}$ $\forall\, r \in R$, $s \in R$, and $m \in M$	$R^2 \times M$
M.11 Firm-level pricing (3.52)	$\tilde{p}_{mrs} = \frac{(1+t_{mrs})\tau_{mrs} c_{mr}}{\tilde{\varphi}(1-1/\sigma^M)}$	$\tilde{q}_{krs}$ $\forall\, r \in R$, $s \in R$, and $k \in K$	$R^2 \times K$
M.12 Bilateral selection: *zero-profit productivity cutoff* (3.72)	$f^M_{mrs} c_{mr} = \frac{\tilde{p}_{krs} \tilde{q}_{krs}}{(1+t_{krs})} \frac{a+1-\sigma^M}{a\sigma^M}$	N_{mrs} $\forall\, r \in R$, $s \in R$, and $m \in M$	$R^2 \times M$
M.13 Zero expected profit: *free-entry* (3.77)	$\delta f^E_{mr} c_{mr} = \sum_{s \in R} \left(\frac{N_{mrs}}{n_{mr}}\right) \frac{\tilde{p}_{mrs} \tilde{q}_{mrs} (\sigma^M - 1)}{(1+t_{mrs}) a \sigma^M}$	n_{mr} $\forall\, r \in R$ and $m \in M$	$R \times M$
M.14 Representative-firm productivity (3.79)	$\tilde{\varphi}_{mrs} = b \left(\frac{N_{mrs}}{n_{mr}}\right)^{-1/a} \left(\frac{a+1-\sigma^M}{a}\right)^{1/(1-\sigma^M)}$	$\tilde{\varphi}_{mrs}$ $\forall\, r \in R$, $s \in R$, and $m \in M$	$R^2 \times M$

Number of Melitz specific equations and variables: $M \times \left(3R + 4R^2\right)$

Much remains to be done

- Melitz code needs to be implemented
- Baseline needs to be calibrated with the new equations
- Test simulations need to be run

Extensions:

- Split out US, incorporate WiNDC state-level disaggregation
- Include labor-leisure option
- Include Krugman option