Quantifying the Welfare Effects of Trade and Trade Policy

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Introduction

• Considerable recent progress quantifying the welfare effects of trade and trade policy

• Entire class of theoretical models with simple sufficient statistics for the welfare effects of trade
  – Share of country’s trade with itself (domestic trade share)
  – Constant elasticity of trade with respect to trade costs (trade elasticity)

• Tractable framework for undertaking counterfactuals for changes in trade policy in this entire class of models
  – Trade wars (Ossa 2019)
  – Brexit (Dhingra, Huang, Ottaviano, Pessoa, Sampson, Van Reenen 2017)

• Methodology enables ex ante policy assessment, that can be enriched with ex post data, to enable evidence-based welfare and policy analysis
Outline

1. Welfare gains from trade
2. Trade policy counterfactuals
3. Application to Brexit
Simple Model of Trade

• Consider the simplest Armington (1969) model of trade
• The UK (country 1) and countries $i = 2, \ldots, N$, each produce a good, differentiated by country of origin
• Consumers in country $n$ choose consumption of each country $i$’s variety to maximize their CES utility, taking prices and incomes as given:

$$U_n = \left( \sum_{i=1}^{N} \left( q_{ni} \left( p_{ni}, w_n \right) \right)^{\frac{\sigma - 1}{\sigma}} \right)^{\frac{\sigma}{\sigma - 1}}, \quad \sigma > 1.$$

• Goods produced with labor under constant returns to scale

$$Y_i = L_i / a_i$$

• Supply of labor is inelastic and given by $\bar{L}_i$
• Markets are perfectly competitive
• Real income in the UK is

\[ \mathbb{W}_1 = \frac{w_1}{P_1} \]

• The Price Index faced by UK consumers is

\[ P_1 = \left[ \sum_{i=1}^{N} p_{1i}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \]
Trade Share and Trade Elasticity

- UK firms charge UK consumers a price

\[ p_{11} = a_1 w_1 \quad \text{Domestic Price} \]

- \( w_1 \) is UK’s wage rate and \( a_1 \) is the number of hours needed to make the UK good.

- Foreign firms from country \( i \) pay trade costs \( \tau_{1i} > 1 \) when shipping to the UK.

- Foreign firms charge UK consumers

\[ p_{1i} = \tau_{1i} p_i = \tau_{1i} a_i w_i \quad \text{Import Price} \]
Trade Share and Trade Elasticity

- Share of UK consumer’s expenditure on country $i$’s goods

$$\pi_{1i} = \left(\frac{p_{1i}}{P_1}\right)^{1-\sigma}$$  \textit{Trade Share}

- As $p_{1i}$ rises, UK consumers reduce their expenditure on goods from $i$ by $-(\sigma - 1)\%$.

- As $p_{1i} = \tau_{1i} a_i w_i$, the \textit{trade elasticity} given by the gravity equation:

$$\ln \pi_{ni} = -(\sigma - 1) \ln \tau_{ni} + \ln a_n w_n + \epsilon_{ni}$$
Domestic Trade Share, Trade Elasticity and Welfare

- \( w_1 = p_1 / a_1 \) (Domestic Price)
- \( \pi_{11} = (p_{11}/P_1)^{1-\sigma} \) (Domestic Trade Share)

Real income in the UK is

\[
\bar{W}_1 = \frac{w_1}{P_1} = \frac{1}{a_1} \left( \pi_{11} \right)^{-\frac{1}{\sigma-1}}
\]

Therefore real income is increasing in own productivity \((1/a_1)\) and decreasing in domestic trade share \((\pi_{11})\)

Open economy domestic trade share \((\pi^T_{11})\) and trade elasticity \(- (\sigma - 1)\) are sufficient statistics for the welfare gains from opening the closed economy to trade \((\pi^A_{11} = 1)\)

\[
\frac{\bar{W}^T_1}{\bar{W}^A_1} = \left( \pi^T_{11} \right)^{-\frac{1}{\sigma-1}}
\]
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Open Economy Equilibrium

- UK income = Expenditure of the World on UK goods

\[
\bar{w}_1 \bar{L}_1 = \sum_{i=1}^{N} \pi_{i1} w_i \bar{L}_i
\]

\[
= \sum_{i=1}^{N} \left( \frac{(\tau_{1i} a_i w_i)^{1-\sigma}}{\sum_{k=1}^{N} (\tau_{ik} a_k w_k)^{1-\sigma}} \right) w_i \bar{L}_i
\]

- \(N\) such equations from each country.
- Determines unique values for the \(N\) equilibrium wages.
Counterfactual Open Economy Equilibrium

• Consider a counterfactual change in trade costs from $\tau_{1i}$ to $\tau'_{1i}$, holding all else constant

• We have analogous counterfactual equilibrium conditions

• Income equals expenditure

\[ w_1 \bar{L}_1 = \sum_{i=1}^{N} \frac{\left( \tau'_{1i} a_i w_i \right)^{1-\sigma}}{\sum_{k=1}^{N} \left( \tau'_{ik} a_k w_k \right)^{1-\sigma}} w_i \bar{L}_i \]

• Real income

\[ \mathbb{W}_1' = \frac{w_1'}{P_1'} = \frac{1}{a_1} \left( \pi'_{11} \right)^{-\frac{1}{\sigma-1}}, \quad \sigma > 1 \]
Exact Hat Algebra

- We can rewrite the counterfactual equilibrium in terms of:
  - Observed values of the endogenous variables in the initial equilibrium
  - Assumed relative changes in trade costs ($\hat{\tau}_{ni} = \tau'_{ni}/\tau_{ni}$)
  - Relative changes of the endogenous variables ($\hat{x}_n = x'_n/x_n$)

\[
\hat{w}_1 Y_1 = \sum_{i=1}^{N} \frac{\pi_{1i} (\hat{\tau}_{1i} \hat{w}_i)^{1-\sigma}}{\sum_{k=1}^{N} \pi_{1k} (\hat{\tau}_{ik} \hat{w}_k)^{1-\sigma}} \hat{w}_i Y_i
\]

- $Y_i = w_i \bar{L}_i$ is initial income (GDP)
- Provides a system of $N$ equations that determines unique values for the $N$ counterfactual changes in wages
- Counterfactual change in real income

\[
\hat{\hat{W}}_n = (\hat{\pi}_{nn})^{-\frac{1}{\sigma-1}}, \quad \sigma > 1
\]
Extensions

- Other reasons for trade
- Intermediate inputs
- Multiple sectors
- Factor mobility (next lecture)
- Multiple factors and distributional consequences of trade
- Endogenous choice of trade policy
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The Economic Impact of Brexit

• What would be the impact of Brexit on the UK economy?

• Long-term economic impact of higher trade costs after Brexit on welfare

\[ \frac{\mathbb{W}_1^\tau'}{\mathbb{W}_1^\tau} \]

• Quantitative trade model of 35 regions and 31 goods and services sectors (Dhingra et al. 2017)
CEP Quantitative Trade Model

- Welfare changes from Leaving the EU, compared to staying are
  \[
  \hat{W}_1 = \frac{1 - T}{1 - T'} \prod_{s,s' = 1}^{S} (\hat{\pi}_{11,s})^{-\beta_{s'} \epsilon_{ss'}}/(\sigma_{s}-1), \quad s, s' \in \{1, 2, ...S\}
  \]

- \( \pi_{11,s} \) = share of expenditure on domestic outputs of sector \( s \).
- \( -(\sigma_{s} - 1) = \) trade elasticity = % fall in import share from a 1% change in bilateral trade costs, holding incomes constant.
- \( T = \) share of tariff revenue in aggregate expenditure
- \( \epsilon_{ss'} = \) elasticity of sector \( s \) price to changes in sector \( s' \) price.
- \( \beta_{s} = \) share of sector \( s \) in UK consumption
- Data on initial expenditure shares, income levels of different countries, consumption shares and worldwide input-output tables.
Brexit Impacts from Quantitative Trade Model

<table>
<thead>
<tr>
<th>Welfare Changes due to UK Withdrawal from the EU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soft Norway-style Brexit (0% Tariffs)</strong></td>
</tr>
<tr>
<td>Due to Increase in EU/UK Tradable Tariffs (0%) +</td>
</tr>
<tr>
<td>Due to Increase in EU/UK Non-Tariff Barriers</td>
</tr>
<tr>
<td>(2% current + 5.7% future)</td>
</tr>
<tr>
<td>Due to Fiscal Benefit</td>
</tr>
<tr>
<td><strong>Total Welfare Change</strong> (£850 per household per year)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Hard No-Deal Brexit (MFN Tariffs)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to Increase in EU/UK Tradable Tariffs (MFN EU Tariffs) +</td>
</tr>
<tr>
<td>Due to Increase in EU/UK Non-Tariff Barriers</td>
</tr>
<tr>
<td>(6% current + 12.8% future)</td>
</tr>
<tr>
<td>Due to Fiscal Benefit</td>
</tr>
<tr>
<td><strong>Total Welfare Change</strong> (£1,700 per household per year)</td>
</tr>
</tbody>
</table>
Brexit Impacts Globally
Brexit Impacts Locally

- For a Local Authority $l$ with different sectors $s$,

\[
\text{Aggregate GVA change in } l = \sum_{s=1}^{S} \text{Employment Share}_{sl} \times \text{National GVA Shock}_s
\]
Local Impacts under Hard Brexit

Source: Dhingra, Machin and Overman (2017)
Local Brexit Impacts to Policy

Source: Dhingra, Machin and Overman (2017)
Developing Evidence-based Policy

• Quantitative modelling enables ex ante assessment of trade policy.

• It can be combined with ex post data to enrich ex ante assessments with
  • Complex channels of impacts other than trade shares
  • Early signs of detection using actual ex post data
  • Unbiased and precise elasticities of economic outcomes to trade
Complex Channels: Sterling Depreciation from the EU Referendum

Source: Costa, Dhingra and Machin (2019)
Early Signs: Sterling Depreciation and Trade Prices

Source: Costa, Dhingra and Machin (2019)
Margins of Adjustment: Sterling Depreciation and Wages

Source: Costa, Dhingra and Machin (2019)
Elasticities

- $p_{11,s} = C_s \left( w_{1s}, p_{1s}^M \right)$ where $p_{1s}^M$ is the price of intermediate goods and services needed to make sector $s$ output in the UK

<table>
<thead>
<tr>
<th>Log(Intermediate Import Price)</th>
<th>log(Wage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log(Intermediate Imports Weighted)</td>
<td>0.375</td>
</tr>
<tr>
<td>Depreciation) X Post-Referendum</td>
<td>(0.100)</td>
</tr>
</tbody>
</table>

controls, Time Dummies, Sector Dummies | Yes | Yes |
Sample Size | 2040 | 123,489 |

- When $p_{1s}^M$ rises by 1%, wage in the sector $w_{1s}$ fall by $-0.201/0.375 = -0.54\%$

- Estimated elasticities range from -0.34 to -0.54
- Calibrating to theory, the elasticity of substitution in production between workers and intermediate imports ranges from -1.82 to -3.80
Elasticities: Real Wage Responses

Source: Costa, Dhingra and Machin (2019)
Conclusion

• Quantitative trade models bring powerful tools for ex ante and ex post assessment of trade policy.

• Statistical methods provide ways of early detection of impacts and capture complex adjustments that are not summarized by trade flows and initial values.

• Together, quantitative and statistical tools in economics enable evidence-based welfare and policy analysis.