Analyzing trade flows

Cosimo Beverelli
Economic Research Division
World Trade Organization
Content

a. Overview and learning objectives

b. Analyzing trade flows

c. Analyzing trade policy

d. Databases
a. Overview and learning objectives

- Main techniques used for trade data analysis
- Overview of trade and trade policy indicators and of the databases needed to construct them
- Main techniques used for trade policy analysis
- Challenges in collecting and analyzing the data, such as measurement errors or aggregation bias
b. Analyzing trade flows

- Descriptive statistics in trade are typically needed to picture the trade performance of a country:
  i. How much does a country trade
  ii. What does it trade
  iii. With whom
1. “How much”

- This question is intimately related to the concept of "trade openness", which typically measures the economy’s ability to integrate in world trade circuits.
- Another measure of the integration of a country into the world economy is the extent to which it is involved in global value chains.
2. “What”

• Trade patterns are determined by a country’s endowment of productive factors and the technology used (comparative advantage in standard trade model)
• Other reasons for trade are love for variety w/ economies of scale, market structure w/ reciprocal dumping
• Some of the underlying factors that give rise to trade are exogenously given by nature (geography), others are the result of policies (e.g. physical and human capital)
• The question of "What" is also directly linked to the question of diversification of a country’s exports, a subject of concern for many governments
3. “With whom”

- The characteristics of a country's trading partners affect how much it will gain from trade
  - For instance, trade links with growing and technologically sophisticated markets can boost domestic productivity growth
- So it matters to know who the home country’s "natural trading partners" are
  - Typically, this depends on geography, infrastructure and other links, such as historical ties.
  - A full discussion of the determinants of bilateral trade is the subject of gravity equations. In this discussion, In this chapter we will limit ourselves to descriptive measures of the geographical composition of a country’s foreign trade and its complementarity with partners
Overall openness

a. Trade over GDP measure

- Let $X^i$, $M^i$ and $Y^i$ be respectively country $i$’s total exports, total imports and GDP. Country $i$’s openness ratio is defined as

$$O_t^i = \frac{X_t^i + M_t^i}{Y_t^i}$$

- The higher $O_t^i$, the more open is the country. For small open economies like Singapore, it may even be substantially above one.
- The Penn World Tables (PWT) include this measure of openness for a large number of years.
- Can we use $O_t^i$ as such for cross-country comparisons?
- No, because it is typically correlated with several country characteristics.
- For instance, $O_t^i$ varies systematically with levels of income.
a. Trade over GDP measure (ct’d)

Source: Authors' calculations from WDI

Source: Authors' calculations from WDI
a. Trade over GDP measure (ct’d)

- Does it matter that openness correlates with country characteristics such as the level of income?
- Yes, for two reasons:
  1. Because "raw" openness embodies information about other country characteristics, it cannot be used for cross-country comparisons without adjustment
  2. For instance, Belgium has a higher ratio of trade to GDP than the United States; but this is mainly because the U.S. is a larger economy and therefore trades more with itself
- If we want to generate meaningful comparisons, we will have to control for influences, such as economic size, which we think are not interesting for the openness ratio. This can be done with regression analysis
a. Trade over GDP measure (ct’d)

2. Suppose that one wants to assess econometrically the influence of openness on growth
   • The measure of openness used as an explanatory variable in the regression analysis will have to be cleaned from influences that may embody either reverse causality (from growth to openness) or omitted variables (such as the quality of the government or institutions, which can affect both openness and growth)
   • In order to get rid of endogeneity bias in growth/openness regression, one must adopt an identification strategy consisting of using "instrumental variables" which correlate with openness but do not influence income except through openness
   • For instance, Frankel and Romer (1999) used distance from trading partners and other so-called "gravity" variables as instrumental variables
   • Using this strategy, they found that openness indeed has a positive influence on income levels
   • Another route consists of using measures of openness based on policies rather than outcomes
b. Import content of exports and external orientation

- The import content of exports is a measure of the outward orientation of an exporting industry.
- The imported input share of industry $k$ can then be calculated as

$$IIS_{kt} = \frac{\sum_{j=1}^{J} \mu_{jt} z_{jk}}{y_{kt}}$$

- $\mu_{jt} = m_{jt}/c_{jt}$, is the import-penetration ratio of good $j$ ($m_{jt}$ is imports of good $j$ and $c_{jt}$ is domestic consumption).
- $z_{jk}$ is industry $k$’s consumption of good $j$ as an intermediate (from IO table).
- $y_{kt}$ is industry $k$’s output.
b. Import content of exports and external orientation (ct’d)

- The net external orientation of industry $k$ is the difference between the traditional export ratio (or "openness to trade" index, $x_{kt}/y_{kt}$) and the imported input share

\[
NEO_{kt} = \frac{x_{kt}}{y_{kt}} - IIS_{kt}
\]

- In practice, these measures are rather difficult to calculate because of heavy data requirement (especially input-output tables and production data)
c. Trade in intermediate goods

• There are two measures proposed in the literature to measure offshoring, both based on input-output tables:

1. Offshoring measure suggested by Feenstra and Hanson (1996) is the ratio of imported intermediate inputs used by an industry to total (imported and domestic) inputs

2. Index of vertical specialization proposed by Hummels et al. (2001) is the value of imported intermediate inputs embodied in exported goods
Trade composition

a. Sectoral and geographical orientation of trade

• The sectoral composition of a country’s trade matters
• It matters for growth if some sectors are drivers of technological improvement
• Moreover, constraints to growth may be more easily identified at the sectoral level

1. Sectoral orientation of trade
   • Share of product $j$ in total exports of country $i$

2. Geographical orientation of trade
   • Share of exports sold in country $c$ in total exports of country $I$
a. Sectoral and geographical orientation of trade (ct’d)

• Using a dataset with sector-level bilateral trade data, we can construct indexes for the share of each sector/country in a country's total exports/imports

• One can go a step further and assess to what extent a country's export orientation is favorable, i.e. to what extent the country exports in sectors and toward partners that have experienced a faster import growth
b. Intra-industry trade

• For many countries, a large part of international trade takes place within the same industry, even at high levels of statistical disaggregation

• A widely used measure of the importance of intra-industry trade is the Grubel-Lloyd (GL) index

\[ GL_{ij}^k = 1 - \frac{|X_{ij}^k - M_{ij}^k|}{X_{ij}^k + M_{ij}^k} \]

• The GL index ranges between zero and one

• If, in a sector, a country is either only an exporter or only an importer, the second term will be equal to unity and, hence, the index will be zero, indicating the absence of intra-industry trade

• If in this sector a country both exports and imports, the index will be closer to one the more similar in value imports and exports are

• High values of the GL index are consistent with the type of trade analyzed in, say, Krugman’s monopolistic-competition model
b. Intra-industry trade (ct’d)

- GL indices should however be interpreted cautiously.
- First, they are lower when calculated at more detailed levels of product aggregation, so comparisons require calculations at similar levels of aggregation.

- Second, unless calculated at extremely fine degrees of disaggregation, GL indices can pick up "vertical trade", a phenomenon that can reflect comparative advantage rather than monopolistic competition.
b. Intra-industry trade (ct’d)

- Typically, similar countries (in terms of economic size, i.e. GDP) share more intra-industry trade with each other

Note: The trade overlap index measures two-way intra-industry trade
c. Export diversification/concentration

- Export concentration in primary products has often been highlighted as a major drawback for development.
- Prebisch (1959) argued that primary product dependence caused:
  - volatile terms of trade
  - slow productivity growth
  - relatively low value added
- Lederman and Maloney (2007) find that any negative impact of resource abundance (net natural resource exports per worker) on growth relates to the high export concentration that is typical of resource exporters.
c. Export diversification/concentration (ct’d)

• Export diversification has the potential to:
  – Reduce the dependence on fluctuating commodity prices and "export riskiness"
  – Diversification into other technology-intensive sectors can trigger knowledge spillovers from the exposure to international markets, management and marketing practices, and production processes
  – Diversification at the extensive margin (new products or exporters) reflects "export entrepreneurship" and, in that sense, is useful evidence on the business climate

• Herzer and Nowark-Lehman (2004), analyzing the Chilean experience, investigate the hypothesis that export diversification is linked to economic growth through externalities of learning activities related with exporting. They conclude that export diversification on the basis of natural resources has a positive influence on growth
c. Export diversification/concentration (ct’d)

• However, one should be careful in taking diversification as a policy objective per se
• For example, diversification has often been justified to avoid the so-called "natural resource curse" (a negative correlation between growth and the importance of natural resources in exports). However, whether the curse is real or a statistical illusion has recently become a matter of controversy
• Increasing levels of export diversification do not guarantee by themselves higher levels of growth. Between the mid-1960s and the late 1990s, most Latin American countries diversified their export structure, but yet they were unable to achieve considerable levels of GDP expansion (see Bebczuk and Berrettoni, 2006)
The simplest measure of export concentration in the Herfindahl concentration index is:

\[ h^i = \sum_k \left( s_k^i \right)^2 \]

Where \( s_k^i \) is the share of sector \( k \) in country \( i \)'s total exports or imports.

The Herfindahl index is sometimes normalized to range from zero to one, in which case it is referred to as Normalized Herfindahl index:

\[ nh^i = \frac{h^i - 1/K}{1 - 1/K} \]

Where \( K \) is the number of products exported or imported.

Alternative measures of concentration are the Gini index or the Theil index.
c. Export diversification/concentration (ct’d)

• The higher the Herfindahl index, the more concentrated exports or imports are in a few sectors

• Observe that the indices are higher on the export side than on the import side for Chile and Peru, whose export structures are rather concentrated on mineral products

• Notice that Herfindahl indexes are large for countries heavily depending on oil exports. For instance, the (normalized) index for Nigeria in 2003 was 0.63 (Comtrade data)
c. Export diversification/concentration (ct’d)

- The World Bank proposes an export diversification index

\[ DX^i = \frac{\sum_k |X_k^i - X_k|}{2} \]

Where \( X_k^i \) is the share of sector \( k \) in country \( i \)'s total exports and \( X^i \) is the share of good \( k \) in world exports

- Available at [WITS](https://wits.worldbank.org)
c. Export diversification/concentration (ct’d)

• If concentration indices such as the Herfindahl index are calculated over active export lines only, they measure concentration/diversification at the intensive margin.
• Diversification at the extensive margin can be measured by counting the number of active export lines.
• One drawback of measuring diversification by just counting active export lines is that whether a country diversifies by starting to export crude petroleum or mules, asses and hinnies is the same: one export line is added (at a given level of product disaggregation).
• Hummels and Klenow (2005) have proposed a variant where new export lines are weighted by their share in world trade.
• Then, starting to export a million dollar worth of crude counts more than starting to export a million dollar worth of asses, because the former is more important in world trade (and therefore represents a stronger expansion potential).
c. Export diversification/concentration (ct’d)

Intensive margin

\[ IM^i = \frac{\sum_{\Omega^i} X^i_k}{\sum_{\Omega^i} X^W_k} \]

Where \( \Omega^i \) is the set of products exported by country \( i \), \( X^i_k \) the value of \( i \)'s exports of product \( k \) to the world, and \( X^W_k \) the value of world exports of product \( k \)
- \( IM \) is \( i \)'s market share in products belonging to \( i \)'s export

Extensive margin

\[ EM^i = \frac{\sum_{\Omega^i} X^{W}_k}{\sum_{\Omega^W} X^W_k} \]

Where \( \Omega^W \) is the set of all traded products
- \( EM \) is the share of products belonging to \( i \)'s export portfolio in world trade
c. Export diversification/concentration (ct’d)

Intensive and extensive margins can also be computed with geographical dimension

- Geographical extensive margin: \(i\)'s share of world export to only those countries that \(i\) exports to in total world exports of all goods
- Geographical intensive margin: share of \(i\)'s exports in total world export to only those countries that \(i\) exports to

Available at WITS
d. Export market penetration

- Typically, a given developing countries will reach only a small fraction of importing countries.
- *Brenton and Newfarmer (2007)* construct an index of export market penetration (IEMP) that measures the extent to which a country is actually exploiting the market opportunities from the existing set of export products.

\[
IEMP^i = \frac{\sum_{k \in \Omega_i} \sum_j Y^i_{kj}}{\sum_{k \in \Omega_i} \sum_j Z^j_{kj}}
\]

Where \( \Omega_i \) is the set of products exported by country \( i \), \( j \) indexes importers, \( Y = 1 \) if \( i \) exports product \( k \) to \( j \), \( Z = 1 \) if \( j \) imports good \( k \).

- For the given range of products that a country exports, then the IEMP will be higher for countries that reach a large proportion of the number of international markets that import that product.
- Note: increasing geographical reach with existing exports is easier than discovering wholly new products for exports...
d. Export market penetration (ct’d)

- This index is positively correlated with GDP per capita

- Countries with relatively low per capita incomes tend to do less well in exploiting the available markets for the goods that they export
e. Export growth decomposition

• Export growth is a particularly important policy concern
• Export expansion, in terms of either products or destinations, can be at:
  – *Intensive margin* (growth in the value of existing exports to the same destination(s))
  – *Extensive margin* (new export items, new destinations)
  – *Sustainability margin* (survival of export spells)
• Brenton and Newfarmer (2007) propose this decomposition of export growth between time 0 and time 1:

\[
\Delta X = \sum_{\Omega_0 \cap \Omega_1} \Delta X + \sum_{\Omega_1 / \Omega_0} X_k - \sum_{\Omega_0 / \Omega_1} X_k
\]

Where \(\Omega_0\) is the set of products exported by a country in a year taken as the base year, and \(\Omega_1\) is the set exported by a country in a terminal year

• 1\textsuperscript{st} term: export variation at the intensive margin
• 2\textsuperscript{nd} term: new-product margin
• 3\textsuperscript{rd} term: product death margin
e. Export growth decomposition (ct’d)

• The contribution of the new-product margin to export growth is generally small

Decomposition of the export growth of 99 developing countries, 1995-2004

• The same story holds for developed countries (1995-2004, Comtrade data)

<table>
<thead>
<tr>
<th>Reporter</th>
<th>$\sum_{K_0 \cap K_1} \Delta X / \Delta Y$</th>
<th>$\sum_{K_1 / K_0} X_k / \Delta Y$</th>
<th>$\sum_{K_0 / K_1} X_k / \Delta Y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>.9784529</td>
<td>.0432978</td>
<td>.0217508</td>
</tr>
<tr>
<td>JPN</td>
<td>1.011665</td>
<td>.0137644</td>
<td>.0254291</td>
</tr>
<tr>
<td>DEU</td>
<td>1.002045</td>
<td>.0079661</td>
<td>.0100109</td>
</tr>
<tr>
<td>FRA</td>
<td>.9663144</td>
<td>.0481832</td>
<td>.0144976</td>
</tr>
<tr>
<td>GBR</td>
<td>.9772262</td>
<td>.1178167</td>
<td>.0950429</td>
</tr>
<tr>
<td>ITA</td>
<td>.9539621</td>
<td>.0632544</td>
<td>.0172165</td>
</tr>
</tbody>
</table>
Comparative advantage

a. Revealed comparative advantage

• The current resurgence of interest for industrial policy sometimes confronts trade economists with demands to identify sectors of comparative advantage
• The traditional measure is the Revealed Comparative Advantage (RCA) index (Balassa, 1965)

\[
RCA^i_k = \frac{X^i_k / X^i}{X^k / X}
\]

• RCA is the ratio of product k’s share in country i’s exports to its share in world trade
• A value of the RCA above 1 in sector k means that i has a revealed comparative advantage in that sector
a. Revealed comparative advantage (ct’d)

• A disadvantage of the RCA index is that it is asymmetric, i.e. unbounded for those sectors with a revealed comparative advantage, but it has a zero lower bound for those sectors with a comparative disadvantage.

• A solution is to rely on a simple normalization proposed by Laursen (2000). The normalized RCA index, NRCA becomes:

\[
NRCA_k^i = \frac{RCA_k^i - 1}{RCA_k^i + 1}
\]

• By construction, NRCA is between -1 and 1.

• RCA can be computed from World Bank’s trade indicators (WITS).
a. Revealed comparative advantage (ct’d)

Change in NRCA between 1980s and 2000s, Chile and Colombia (TTP data)

- In Chile, almost all sectors experienced an increase in the NRCA index, but most of the sectors with revealed comparative disadvantage did not gain comparative advantage.
- In Colombia, a few sectors that had a revealed comparative disadvantage in the 1980s gained comparative advantage in the 2000s.
b. Export specialization index

- The export specialization index is a modified RCA index

\[
ES_k^i = \frac{X_k^i / X^i}{M_k^j / M^j}
\]

- The denominator is the share of imports of product \( k \) in country \( j \)'s total imports
- \( ES \) provides product information on revealed specialization in the export sector of a country not vis-à-vis the world, like RCA, but rather vis-à-vis specific markets or partners
- The value of the index less than unity indicates a comparative disadvantage and a value above unity represents specialization in this market
- Available at WITS
c. Revealed technology content

• The PRODY index developed by Hausmann et al. (2007) ranks sectors in terms of their productivity/income content

\[ PRODY_k = \sum_i \frac{RCA^i_k}{\sum_i RCA^i_k} Y^i \]

• The index is a weighted average of the GDP per capita of the countries that export in sector \( k \), where the weights are a measure of the exporter’s RCA indices in sector \( k \) (RCA are adjusted to sum up to one)
c. Revealed technology content (ct’d)

- By construction, sectors with high values of PRODY are those where high income countries play a major role in world exports.
- Under the reasonable assumption that high income/high wage countries display a strong presence where comparative advantages are determined by factors other than labor cost (such as know-how, technological content, intrinsic quality, and so on), sectors with a high PRODY index are more sophisticated than sectors with a low value of the index.

<table>
<thead>
<tr>
<th>Product (k)</th>
<th>HS6</th>
<th>Prody_k</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Equine hides and skins, raw</td>
<td>410140</td>
<td>517.7</td>
</tr>
<tr>
<td>2 Sisal and Agave, raw</td>
<td>530410</td>
<td>766.81</td>
</tr>
<tr>
<td>3 Cloves (whole fruit, cloves and stems)</td>
<td>90700</td>
<td>892.15</td>
</tr>
<tr>
<td>4 Vanilla beans</td>
<td>90500</td>
<td>927.77</td>
</tr>
<tr>
<td>5 Natural uranium, its compounds, mixtures</td>
<td>284410</td>
<td>982.94</td>
</tr>
<tr>
<td>4955 Nuclear reactors</td>
<td>840110</td>
<td>31565.67</td>
</tr>
<tr>
<td>4956 Railway cars nes, open, with sides &gt; 60 cm high</td>
<td>860692</td>
<td>31677.95</td>
</tr>
<tr>
<td>4957 Calcium-ammonium nitrate mix, double salts pack &gt;10kg</td>
<td>310260</td>
<td>31783.25</td>
</tr>
<tr>
<td>4958 Vinyl chloride (chloroethylene)</td>
<td>290321</td>
<td>31826.73</td>
</tr>
<tr>
<td>4959 Leucite, nepheline and nepheline syenite</td>
<td>252930</td>
<td>32218.66</td>
</tr>
</tbody>
</table>
c. Revealed technology content (ct’d)

• Hausmann et al. (2007) also construct a quantitative measure of the sophistication of the overall specialization pattern of each country, EXPY

\[ \text{EXPY}^i = \sum_k \frac{X_k^i}{X^i} \text{PRODY}_k \]

• EXPY is a weighted average of the PRODY for country \( i \), using product \( k \)'s share in country \( i \)'s exports as weights
• EXPY is productivity content associated to the export vector of a country
• Products that are exported by rich countries get ranked more highly than commodities that are exported by poorer countries
• There is a positive relationship between EXPY and per capita GDP
• This is partly by construction, since a commodity’s PRODY is determined by the per capita GDPs of the countries that are important exporters of that commodity...
c. Revealed technology content (ct’d)

• ...Hausmann et al. (2007) show that this relationship is not just a mechanical one: excluding own exports from the calculation PRODY index (in this case the index becomes country specific) does not change the results much.
c. Revealed technology content (ct’d)

- Hausmann et al. (2007) show that the index is correlated with GDP growth.
- Countries that export goods associated with higher EXPY are those who also grow more rapidly, even after controlling for initial income per capita, human capital levels, and time-invariant country characteristics.
- What an economy exports matters: rich (poor) countries export products that tend to be exported by other rich (poor) countries.
- *Ceteris paribus*, producing and exporting goods that richer countries export represent an effective route to faster growth.
d. Revealed factor intensity

- A recent database constructed by UNCTAD (Shirotori et al., 2010) estimates "revealed" factor intensities of traded products
- Good $k$’s revealed intensity in (physical) capital is

$$ rki_k = \sum_{\Omega_k} \frac{RCA^i_k}{RCA^i_k} k^i $$

Where $k^i = K^i/L^i$ is country $i$’s stock of capital per worker (national factor endowment)

- "Revealed" means that a product exported by a country that is richly endowed in physical capital, is supposed to be capital intensive
  - For instance, if good $k$ is exported essentially by Germany and Japan, it is revealed to be capital-intensive. If it is exported essentially by Vietnam and Lesotho, it is revealed to be labor-intensive
- A similar expression is constructed for the revealed intensity in other factors, such as human capital
- Data available [here](#)
Regional trade

- Preferential Trade Agreements (PTAs) are very much in fashion

- The surge in PTAs has continued unabated since the early 1990s. Some 474 PTAs have been notified to the GATT/WTO up to July 2010

- Almost 300 preferential trade agreements (notified and not notified) were in force in 2010
Regional trade

• Here we discuss how to construct simple indicators of regional trade

a. Intra-regional import matrix

Source: Author calculations from TPP database

• Observe the overwhelming weight of Brazil and Argentina in regional trade
b. Regional intensity of trade

- Regional Intensity of Trade (RIT) indices measure, on the basis of existing trade flows, to what extent countries trade with each other more intensely than with other countries.

\[
TI_j^i = \frac{X_j^i / X^i}{X_j^W / X^W}
\]

Where \(X_j^i\) is \(i\)'s exports to \(j\), \(X^i\) is \(i\)'s total exports, \(X_j^W\) is world exports to \(j\), \(X^W\) is world exports.

- \(TI\) is the ratio of the share of a country’s exports going to a partner over the share of world exports going to the same partner.
- An index of more (less) than one indicates a bilateral trade flow that is larger (smaller) than expected, given the partner country’s importance in world trade.
- \(TI\) provides information on the potential welfare effects of a regional integration agreement.
b. Trade complementarity

- Trade Complementarity Index (TCI) measures the extent to which two countries are "natural trading partners", in the sense that what a country exports overlaps with what the other country imports.

\[
TC^i_j = 100 \left[ 1 - \left( \sum_k m_k^i - x_k^j \right) / 2 \right]
\]

Where \( m_k^i \) is sector \( k \)'s share in \( i \)'s total imports from the world and \( x_k^j \) is sector \( k \)'s share in \( j \)'s total exports to the world.

- The index is zero when no goods are exported by one country or imported by the other and 100 when the export and import shares exactly match.
b. Trade complementarity (ct’d)

Chile’s TCI (import side)

- Chile’s TCIs have increased over time, however the indexes in panel (a) are lower than the ones in panel (b), indicating that for Chile patterns of import complementarity are more developed with North American than with neighboring countries.
Content

a. Overview and learning objectives

b. Analyzing trade flows

c. Analyzing trade policy

d. Databases