**Offshoring, Terms of Trade and**

**the Measurement of U.S. Productivity Growth**

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Based on: “Offshoring Bias in U.S. Manufacturing: Implications for Productivity and Value Added” (w/ Susan Houseman, Christopher J. Kurz, and Paul Lengermann).

“Effects of Terms of Trade Gains and Tariff Changes on the Measurement of U.S. Productivity Growth” (w/ Robert C. Feenstra, Marshall B. Reinsdorf and Matthew J. Slaughter), and

The views expressed in this paper are those of the authors, not those of the Board of Governors of the Federal Reserve System or the Bureau of Economic analysis.**I. Motivation:**

1. Acceleration in U.S. productivity growth after 1995, simultaneous with a major improvement in the U.S. terms of trade



1. This productivity acceleration was particularly pronounced in the manufacturing sector.

These contrasting trends are reconciled through the lens of productivity. Labor productivity for manufacturing rose avg. annual rate 4.1 % compared to 2.7% all nonfarm business, 1997-2007.

1. But in suggesting a link between the terms of trade and productivity, we need to recognize that in theory, improvement the terms of trade *do not* have a first-order impact on value added or productivity when tariffs are small (e.g., Kehoe and Ruhl, 2007)
   * Intuition: terms of trade affect both real output and real inputs in an offsetting manner, thus terms of trade effects do not have a large impact on real value added.
2. We illustrate the terms of trade – productivity link in two ways:
   * In theory, real value added measures are affected by trade prices in the presence of ad valorem tariffs. We will extend Kehoe-Ruhl to a multi-sector setting and show this result.
   * What about if the terms of trade are mismeasured due to index number issues?
3. In that case, we will argue that the mismeasurement in the terms of trade spills over into productivity growth. If the improvement in the terms of trade is *understated*, then productivity is *overstated*.

This logic also applies to industry statistics.



That is suggested by e.g. Michael Mandel, “The Real Cost of Offshoring.” *Business Week,* June 18, 2007.



1. Indeed, part of the reason that manufacturing employment is declining is the substitution of foreign-made inputs for those previously produced domestically.
2. One might expect that these large increases in foreign input shares corresponded to decreases in the relative price of imported intermediates, but official statistics actually indicate the opposite.
3. We address this issue by:
   * Identifying a bias to measured input price indexes from offshoring analogous to outlet substitution bias in CPI literature. Price indexes generally fail to capture price drops associated w/entry & market share expansion of low-cost supplier.
   * Correcting for the bias using in input prices using a formula-based adjustment due to Diewert & Nakamura (2010) and estimating its quantitative importance in a growth accounting decomposition of manufacturing MFP.

**Conclusions:**

* + The growth rates of our alternative materials input price indexes are as much as   
    1 ppt. per year lower than the growth rate of official statistics.
  + This mismeasurement can account for about 0.3 ppt. per year, or about 15% of the annual value added growth for the U.S. manufacturing sector over the past decade.

**Broader Implications**

* More balanced view of the performance of the U.S. manufacturing sector.
  + “Lean and productive” vs. “hollowed out”
* International trade is more important in driving the U.S. economy than official statistics suggest.
* Measurement errors in import prices are themselves a byproduct of globalization.

**Outline:**

*Today:*

II. Measurement of Productivity Growth with International Trade

III. Measurement of Input Prices & Impact of ‘Offshoring Bias’

*In the papers:*

IV. Alternative terms of trade indexes

V. Adjusted U.S. Productivity Growth due to Tariffs and Offshoring

**II. Measurement of Productivity Growth with International Trade**

* Final goods i = 1,…,M final goods, with quantities > 0 and prices  > 0
* Exports i = 1,…,N, with quantities > 0 and international prices > 0.
* Imported intermediate inputs i = 1,…,N, in j = 1,…,C varieties indexed by country
* Import quantities > 0, international prices > 0, domestic prices .

The vector of final goods and free-trade prices is denoted by Pt = (pt,,), and the quantities of these goods are yt = (qt,xt, mt) > 0. Then the ***revenue function*** for the economy is:

Rt(Pt, τt, vt) ≡ 

The revenue function equals the total value added with tariffs *included* in costs of intermediate inputs. But tariffs are *excluded* from the cost of imports in GDP.

Let  denote the value of exports and let  denote the value of imports at duty-free prices. Then nominal GDP is:

GDPt ≡ + (Xt – Mt) .

Substituting for Xt and Mt, we can re-write nominal GDP as the function:

Gt(Pt, τt, vt) = Rt(Pt, τt, vt) ,

which differ by the amount of tariff revenue.

Use the GDP

function to obtain the optimality of free trade in a small open economy:

**Proposition 1**

Holding fixed Pt and vt, the value of GDP is maximized at τt = 0.

This familiar result has a very important implication for the measurement of productivity.

We begin by defining “true” productivity, as in Diewert and Morrison (1986):

, or .

These concepts of productivity change are not measurable because both the numerator of At-1 and the denominator of At are unobservable. Yet their geometric mean *can be* measured, once we assume a specific form for the revenue function.

In particular, suppose that the revenue function takes a nested form:

* In the first stage, for imported varieties , we suppose that the revenue function in (1) is a CES function with elasticity σi,

= , i=1,…,N.

* For now suppose these prices are available, with .
* Then in the second stage, suppose that the revenue function is a translog function over the prices  and endowments.
* We further assume that the observed outputs and inputs are revenue-maximizing.

Then it follows from Diewert and Morrison (1986) that:

=/ [PT(,,yt-1,yt) QT(vt-1, vt, wt-1, wt)] ,

where PT(,,yt-1,yt) is a Törnqvist price index over final goods, exports and imports, and QT(vt-1, vt, wt-1, wt)is a Törnqvist quantity index over primary factors.

The Törnqvist price index is defined as:

ln PT(,,yt-1,yt)

≡

.

Note that imports receive a negative weight since they are inputs.

In comparison, conventional estimates of aggregate TFP are computed as:

TFPt ≡/ [PE(Pt-1,Pt,yt-1,yt) QE(wt-1,wt,vt-1,vt)],

Compare with:

=/ [PT(,,yt-1,yt) QT(vt-1, vt, wt-1, wt)] ,

* “True” productivity has tariffs appearing in Rt, Rt-1 and the price index PT
* Measured TFP excludes tariffs from Gt, Gt-1 (GDP=C+I+G+X–M, with imports measured at duty-free prices) and the price index PE
* But despite this apparent consistency, the *quantities* of outputs and inputs are chosen at tariff-distorted prices in measured TFP and will respond to changes in tariffs. The impact of these quantity responses is shown by:

**Proposition 2**Assume that technology, prices and endowments do not change between periods, so that St-1= St, Pt-1= Pt, and vt-1= vt. Then reducing tariffs from τt-1 ≠ 0 to τt = 0 ⇒ TFPt > 1, even though, indicating that there is no “true” productivity change.

A similar result holds for changes in the terms of trade in the presence of tariffs:

**Proposition 3**Assume that technology and endowments do not change between periods, so that St-1= St and . Then TFPt ≠ 1 due to changing prices only if τt-1 ≠ 0 or τt ≠ 0.

When the import or export prices indexes are mismeasured (or when tariff changes are large) then the mismeasurement of TFP is *not* small. Several source of mismeasurement:

* The BEA uses 5-digit Enduse export and import prices indexes that it obtains from BLS. These are Laspeyres indexes, denoted  and .
* BLS prices do not correct for tariffs, and do not correct for import variety

The BEA uses a Fisher formula to aggregate detailed indexes from BLS to obtain the GDP deflator, but for convenience write the GDP deflator PE(Pt-1,Pt,yt-1,yt) as the Törnqvist formula

For convenience, also use a Törnqvist formula for QE(wt-1,wt,vt-1,vt) .

Then the difference between measured and “true” TFP growth is:

ln TFPt –= 

+



 .

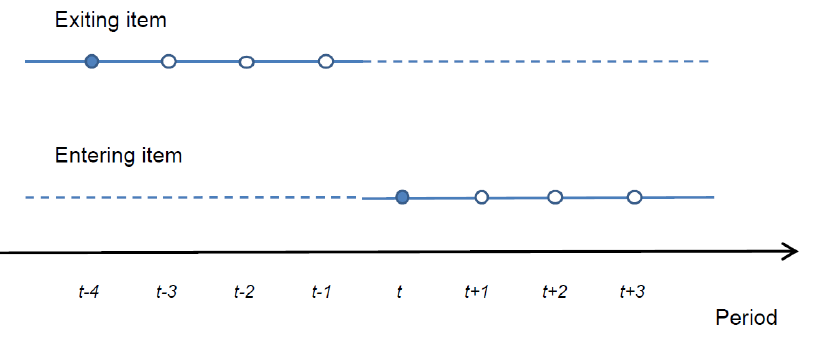
***Several terms:***

* Difference between “true” export prices and Laspeyres formula
* Difference between “true” import prices and Laspeyres formula
* Correction for tariffs in the “true” import prices and weights
* Also need to correct for import variety in the “true” import prices

**3. Measurement of Input Prices & Impact of ‘Offshoring Bias’**



* BLS constructs price indexes for imports (IPP) and domestically produced (PPI)
* BEA aggregates IPP and PPI via Fischer index-number formula to form intermediate input price indexes
* **Hypothetically, price declines from low-cost foreign supplier could be captured in import & input price indexes if:**
  + Foreign supplier enters U.S. market with price comparable to domestic suppliers—drops price and expands market share *after* entry
  + Foreign supplier picked up in import price sample soon after entry
* **More likely, price declines missed:**
  + Foreign supplier enters with lower prices or has lower by time new imported item sampled—observationally equivalent to new good, price change missing
  + Quality-adjusted price of foreign supplier temporarily lower—period of disequilibrium during which it gains market share as it becomes known, its reliability established, & purchasers’ contracts with domestic supplier expire
* **Problem analogous to “outlet substitution bias” in CPI (Reinsdorf 1993, Diewert 1998, Hausman 2003)**
* Illustration of ‘offshoring bias’: The matched model index computes price changes for the same item in two adjacent periods. Since t-1 is unobserved from the perspective of IPP, the entering item is not included in (‘linked out of’) the index in its initial period.
* The level difference between exiting items in the PPI and entering items in the IPP is not observed.



* Example of ‘offshoring bias’:

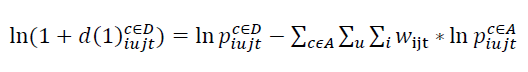


* Bias to input price index at elemental level from shifts in sourcing (Diewert and Nakamura, 2009):

***Bias ≈ (1 + i)\* s\*d***

Where *i* is the rate of price increase, *s* is share captured by new, low-cost supplier, and *d* is percent discount of the low-cost supplier (foreign) relative to the high-cost (domestic) supplier

* Characterization of bias to input price from offshoring identical to that of bias to CPI from outlet substitution (Diewert 1998)
* Evidence of shifting shares (**s**):
* Evidence of the offshoring discount (**d**):
  + **Method 1 - Full Sample IPP Microdata:**
    - The import price discount for an individual item in the developing set is defined as:



* + - Discount aggregated further using IPP item- and establishment-level weights



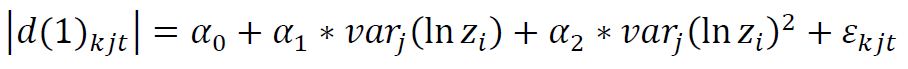
* Evidence of the offshoring discount (**d**), cont’d:
  + **Method 2 - Switching Sample:**
    - A closer empirical counterpart to the decision of U.S. producers to offshore is the decision of U.S. importing firms to switch among foreign source countries
    - Controls (to a greater extent) for cross-firm variation in import composition



* Evidence of the offshoring discount (**d**), cont’d:
  + **Method 3 - Full Sample: Adjusted Estimates**
    - Estimate degree of unobserved compositional differences driving relative prices
    - Products with a high correlation of price skewness and firm size skewness are classified as high quality scope industries (Mandel, 2010)
    - Intuition:



* + - Implementation:



* Evidence of the offshoring discount (**d**), cont’d:

|  |  |  |
| --- | --- | --- |
| * + Unadjusted Full Sample   63% for developing  58% for intermediate | * + Switching Estimates   44% for developing  28% for intermediate | * + Adjusted Full Sample   25% for developing  14% for intermediate |

* + Industry case studies:



* Bias-Corrected Intermediate Input Cost Inflation

**Conclusions**

* Terms of trade affect real value added measures in the presence of tariffs and/or when international prices are mismeasured
* Imported materials made a large contribution to the growth of the U.S. manufacturing sector between 1997-2007, and materials from developing countries represent the largest and fastest growing portion. Input price mis-measurment due to this phenomenon has distorted recent trends in value added and productivity
* VA growth overstated by 0.2 to 0.5 ppt.
  + Reverse VA in manufacturing to NFB growth comparison
* MFP growth in manufacturing overstated by 0.1 to 0.2 ppt. per year
  + Bias is on par with other input contributions, such as capital, labor, and services

**Broader Implications**

**Offshoring bias is neither limited to manufacturing….**

* + Reinsdorf &Yuskavage (2009): productivity growth in the distribution and transportation sectors also appears implausibly large

**…nor to intermediate material inputs:**

* + substitution of imported for domestic capital may not be captured in capital price deflators
  + The same problem arises from services offshoring, where data are extremely limited

**One possible solution: develop a true input price index**

* + Alterman (2009) has proposed an input price index based on a survey of purchasers

**4. Adjusted Productivity Growth for the U.S. Manufacturing Sector**

* Growth Accounting: Data
  + The GDP-by-industry accounts:
    - gross output, intermediate inputs, value added, and their respective chain-type price indexes
  + Industry-level capital stocks derived from BEA’s fixed assets accounts
    - Assets by industry aggregated using ex-post rental prices
  + Labor input is measured as hours worked
    - Hours worked adjusted for labor quality using CBP data
  + BEA provided us with unpublished, detailed import prices and values for 386 commodities and for 502 industries
    - Values and prices available at 6-digit I-O commodity level
    - BEA estimates commodity imports using “import comparability assumption”
* Growth Accounting Data: Imported Intermediates
  + BEA concords BLS IPP prices on an SITC basis to BEA commodity codes
  + Create Laspeyres imported intermediate price indexes for the 65 industries in the published GDP-by-industry accounts
  + We chain-strip using out prices and nominal values for domestic materials
* Growth Accounting
  + Growth accounting decomposes the sources of growth among the factors that drive economic activity.
  + Growth in real gross output (shipments) decomposed into real growth in inputs—capital, labor, energy, services, and materials
  + Productivity growth (output growth not accounted for by input growth)



* + Importantly, after adjusting published estimates of import and input prices to account for offshoring bias, we derive alternative estimates of the contribution from intermediates and re-estimate MFP.
* Growth Accounting: Baseline Results



* Offshoring bias to manufacturing MFP



* Offshoring bias to manufacturing value added



**Conclusions**

* Imported materials made a large contribution to the growth of the U.S. manufacturing sector between 1997-2007, and materials from developing countries comprise the largest and fastest growing portion.
* Price mis-measurment due to this phenomenon has distorted recent trends in productivity and value added
* MFP growth in manufacturing overstated by 0.1 to 0.2 ppt. per year
  + Bias is on par with other input contributions, such as capital, labor, and services
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