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Why trade matters after all☆

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ABSTRACT

I show that accounting for cross-industry variation in trade elasticities greatly magnifies the estimated gains from trade. The main idea is as simple as it is general: while imports in the average industry do not matter too much, imports in some industries are critical to the functioning of the economy, so that a complete shutdown of international trade is very costly overall.

1. Introduction

Either the gains from trade are small for most countries or the workhorse models of trade fail to adequately capture those gains. This uncomfortable conclusion seems inevitable given recent results in quantitative trade theory. As shown by Arkolakis et al. (2012), the gains from trade can be calculated in the most commonly used quantitative trade models from the observed share of a country's trade with itself, λ_j, and the elasticity of aggregate trade flows with respect to trade costs, ε, using the formula $G_j = (\lambda_j)^{-\frac{1}{\varepsilon}}$.[1] Using standard methods to obtain estimates of λ_j and ε, I show below that this implies that a move from complete autarky to 2007 levels of trade would increase real income by only 16.5% on average among the 50 largest economies in the world.

In this paper, I argue that the workhorse models of trade actually predict much larger gains once the industry dimension of trade flows is taken into account. The main idea is as simple as it is general: while imports in the average industry do not matter too much, imports in some industries are critical to the functioning of the economy, so that a complete shutdown of international trade is very costly overall. In particular, I show that the above formula can be written as $G_j = (\lambda_j)^{-\overline{\frac{1}{\varepsilon_j}}}$ in a multi-industry environment, where the aggregate $\overline{\frac{1}{\varepsilon_j}}$ is now a weighted average of the industry-level $\frac{1}{\varepsilon_s}$. The point is that if ε_s is close to zero in some industries, $\frac{1}{\varepsilon_s}$ is close to infinity in these industries which is sufficient to push $\overline{\frac{1}{\varepsilon_j}}$ up a lot. Loosely speaking, ε is a weighted average of ε_s so that the exponent of the aggregate formula is the *inverse of the average* of the trade elasticities whereas the exponent of the industry-level formula is the *average of the inverse* of the trade elasticities.

I make this point in the context of a simple Armington (1969) model in which consumers have CES preferences within industries and goods are differentiated by country of origin. As is well-known, the trade elasticities then depend on the elasticities of substitution through the simple relationship $\varepsilon_s = \sigma_s - 1$. Estimating these elasticities at the 3-digit level using the standard method developed by Feenstra (1994) and refined by Broda and Weinstein (2006), I show that the industry-level formula predicts that a move from autarky to 2007 levels of trade increases real income by 48.6% on average which is around three times the number the aggregate formula predicts. It increases even further once I allow for non-traded goods and intermediate goods which have opposing effects on the gains from trade. All things considered, I find that the gains from trade average 55.9% among the 50 largest economies in the year 2007.[2]

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[1] This includes the Armington (1969) model, the Krugman (1980) model, the Eaton and Kortum (2002) model, and the Melitz (2003) model. The aggregate trade elasticity ε corresponds to different structural parameters in different models.

[2] While my general point also extends to imperfectly competitive gravity models such as Krugman (1980) and Melitz (2003), the particular gains from trade predicted by my multi-sector Armington (1969) model are only exactly the same in other perfectly competitive gravity models such as Eaton and Kortum (2002). This is because the exact isomorphism between "old" and "new" trade models does not apply in the case of multiple industries as shown by Arkolakis et al. (2012). However, recent calculations by Costinot and Rodriguez-Clare (2014) suggest that even with multiple industries the gains from trade are quite similar in "old" and "new" trade models.

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While my point may seem obvious once stated, I believe it has not been made explicitly before. Arkolakis et al. (2012) briefly discuss a multi-industry formula in an extension but never contrast it to their aggregate formula or use it to actually calculate the gains from trade. Caliendo and Parro (2015), Hsieh and Ossa (2012), Ossa (2014), and others work with multi-industry versions of standard trade models but also do not point out that cross-industry heterogeneity in the trade elasticities has the potential to greatly magnify the gains from trade. Closest in spirit is perhaps the contribution by Edmond et al. (2012) which measures the gains from trade originating from pro-competitive effects in an oligopolistic trade model. A key finding is that such pro-competitive effects are large if there is a lot of cross-industry variation in markups which is the case if there is a lot of cross-industry variation in the elasticities of substitution.[3]

Having said this, Costinot and Rodriguez-Clare (2014) perform closely related calculations in recently published contemporaneous work. In particular, they also work out the gains from trade using the aggregate and industry-level formulas considering cases with and without intermediate goods. While my analysis features more industries (252 instead of 31), features more countries (50 instead of 34), and uses different data (GTAP instead of WIOD), the main distinction lies in the elasticity estimates. Instead of relying on elasticity estimates from the literature, I estimate them using the Feenstra (1994)–Broda and Weinstein (2006) approach. This allows me to estimate confidence intervals for the elasticities and, in turn, also confidence intervals for the gains from trade. Overall, the gains from trade appear to be quite precisely estimated with the average 95% confidence interval ranging from 49.3% until 62.5%.

The remainder of this paper is divided into four sections. In Section 2, I develop a multi-industry Armington (1969) model of trade in final and intermediate goods and show what it implies for the measurement of the gains from trade. In Section 3, I describe the data and discuss all applied aggregation, interpolation, and matching procedures. In Section 4, I discuss the elasticity estimation and give an overview of the obtained results. In Section 5, I report the gains from trade for 50 countries in the world and document that a small share of industries typically accounts for a large share of the gains from trade.

2. Model

There are N countries indexed by i or j and S industries indexed by s or t. In each country, consumers demand an aggregate final good C_j^F and industry t producers demand an aggregate intermediate good $C_j^{I,t}$. These aggregate goods are Cobb–Douglas combinations of industry-specific goods C_{js}, $C_{js} = C_{js}^F + \sum_{t=1}^{S} C_{js}^{I,t}$, which are in turn CES aggregates of industry-specific traded varieties C_{ijs} differentiated by the location of their production. To be clear, C_{ijs} denotes the quantity of the industry s traded variety from country i available in country j and it is at that level of disaggregation that trade physically takes place. In sum,

$$C_j^F = \prod_{s=1}^{S} \left(\frac{C_{js}^F}{\alpha_{js}} \right)^{\alpha_{js}} \tag{1}$$

$$C_j^{I,t} = \prod_{s=1}^{S} \left(\frac{C_{js}^{I,t}}{\gamma_{js}^t} \right)^{\gamma_{js}^t} \tag{2}$$

$$C_{js} = \left(\sum_{i=1}^{N} C_{ijs}^{\frac{\sigma_s - 1}{\sigma_s}} \right)^{\frac{\sigma_s}{\sigma_s - 1}} \tag{3}$$

Notice that I allow the Cobb–Douglas shares of the aggregate intermediate good to vary by country j, upstream industry s, and downstream industry t, which allows me to match input–output tables from around the world. The aggregate final good translates one-for-one into utility U_j. The aggregate intermediate good is combined with labor L_{is} using a Cobb–Douglas technology to produce the country-industry-specific traded varieties Q_{is} with total factor productivities A_{is}. In combination, these assumptions imply:

$$U_j = C_j^F \tag{4}$$

$$Q_{is} = A_{is} \left(\frac{L_{is}}{\beta_{is}} \right)^{\beta_{is}} \left(\frac{C_i^{I,s}}{1 - \beta_{is}} \right)^{1 - \beta_{is}} \tag{5}$$

There is perfect competition and the shipment of an industry s traded variety from country i to country j involves iceberg trade barriers $\tau_{ijs} > 1$ in the sense that τ_{ijs} units must leave country i for one unit to arrive in country j so that $Q_{is} = \sum_{j=1}^{N} \tau_{ijs} C_{ijs}$.[4] The model can be solved by invoking the standard requirements that consumers maximize utility, firms maximize profits, firms make zero profits, and all markets clear. Since the model's solution should be intuitive to most readers, I confine myself to sketching some core aspects here.

The value of industry s trade flowing from country i to country j, X_{ijs}, follows the gravity equation $X_{ijs} = p_{ijs}^{1-\sigma_s} P_{js}^{\sigma_s - 1} E_{js}$, where P_{ijs} is the price of the industry s variety from country i in country j, P_{js} is the ideal price index of all industry s varieties available in country j, and E_{js} is total expenditure on all industry s varieties in country j originating from final and intermediate demand. Moreover, $p_{ijs} = A_{is}^{-1} (w_i)^{\beta_{is}} \left(P_i^{I,s}\right)^{1-\beta_{is}} \tau_{ijs}$, where $(w_i)^{\beta_{is}} \left(P_i^{I,s}\right)^{1-\beta_{is}}$ is a cost term aggregating over the wage w_i and the price index of the aggregate intermediate good demanded by industry s, $P_i^{I,s} = \prod_{t=1}^{S} P_{it}^{\gamma_{it}^s}$. Combining these elements, the above gravity equation becomes

$$X_{ijs} = \left(A_{is}^{-1} w_i^{\beta_{is}} \prod_{t=1}^{S} P_{it}^{\gamma_{it}^s (1-\beta_{is})} \tau_{ijs} \right)^{1-\sigma_s} P_{js}^{\sigma_s - 1} E_{js} \tag{6}$$

Defining $\lambda_{js} \equiv X_{jjs}/E_{js}$ as the own trade share in industry s of country j, the above equation implies $P_{js} = A_{js}^{-1} \lambda_{js}^{\frac{1}{\sigma_s - 1}} w_j^{\beta_{js}} \prod_{t=1}^{S} P_{jt}^{\gamma_{jt}^s (1-\beta_{js})}$, which is a system of equations that is log-linear in P_{js}. As is easy to verify, its solution is $P_{js} = w_j \prod_{t=1}^{S} \left(A_{jt}^{-1} \lambda_{jt}^{\frac{1}{\sigma_t - 1}} \right)^{\delta_{jt}^s}$, where δ_{jt}^s is element (s, t) of matrix $(\mathbf{I} - \mathbf{B}_j)^{-1}$ with $\mathbf{I}$ denoting the identity matrix and $\mathbf{B}_j$ denoting the matrix whose element (s, t) is $\gamma_{jt}^s (1 - \beta_{js})$. Readers familiar with input–output analysis will recognize $(\mathbf{I} - \mathbf{B}_j)^{-1}$ as the transpose of the Leontief inverse which implies that δ_{jt}^s is a measure of the importance of industry t in the production process of industry s. In particular, a total of \$ δ_{jt}^s worth of industry t goods is required to meet \$1 worth of industry s final demand. This value combines industry t goods used as inputs in industry s directly as well as industry t goods used as inputs in other industries which then also produce inputs for industry s.[5]

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[3] Related points have, of course, also been made in other areas of macroeconomics. For example, Nakamura and Steinsson (2010) show how cross-industry heterogeneity in menu costs substantially increases the degree of monetary non-neutrality. Also, Jones (2011) argues that cross-industry complementarities through intermediate goods matter a great deal for understanding cross-country differences in incomes.

[4] As usual, I set $\tau_{iis} = 1$ throughout. Even though I refer to C_{ijs} as traded varieties, the model can also accommodate non-traded ones by letting the corresponding $\tau_{ijs} \to \infty$.

[5] I thank a referee for suggesting this way of modeling input–output linkages which is more general than what I had originally done. It is based on section 3.4 of Costinot and Rodriguez-Clare (2014) and explained in more detail in their online appendix.