Multinational Firms and the Structure of International Trade: Online Appendix

Pol Antràs
Harvard University and NBER

Stephen R. Yeaple
Pennsylvania State University and NBER

January 2013

Abstract

This Online Appendix includes various proofs and details that were left out of our Handbook Chapter "Multinational Firms and the Structure of International Trade" due to space constraints. This Appendix is included in the NBER Working Paper Version of the manuscript.

A Theory Appendix: Proofs of Some Results

A.1 Horizontal FDI Model with Asymmetric Countries in Section 4.1.B

In this Appendix, we provide a more complete characterization of the variant of the Markusen and Venables (2000) paper we have developed in section 4.1.B.

Likelihood of Equilibrium without Multinational Firms

In the main text, we have shown that for a Krugman-style equilibrium with only exporting (and no MNE activity) to exist, it needs to be the case that

$$\frac{\left(\frac{w^H}{w^F}\right)\left(\tau^{\sigma-1}-\left(\frac{w^H}{w^F}\right)^{-\sigma}\right)+\tau^{\sigma-1}-\left(\frac{w^H}{w^F}\right)^{\sigma}}{\left(\frac{w^H}{w^F}+1\right)\left(\tau^{\sigma-1}-1\right)}\frac{f_D+f_E}{f_D+\frac{1}{2}f_E}<\frac{\tau^{\sigma-1}+1}{\tau^{\sigma-1}}. \tag{1}$$

The fact that a higher f_D/f_E makes it easier for condition (1) to hold is obvious. The negative effect of τ on the likelihood of a pure exporting equilibrium, can be verified by direct (though cumbersome) differentiation. In particular, note that the right-hand-side of (1) is obviously decreasing in τ, while the left-hand-side is increasing in τ provided that $(\omega^\sigma-1)(\omega^\sigma-\omega)>0$, where $\omega\equiv w^H/w^F$, which is true unless $\omega=1$, in which case the derivative is 0.

We next show that the left-hand-side of (1) attains a unique maximum at $\omega\equiv w^H/w^F=1$, and thus the likelihood of a no-MNE equilibrium is lowest when $w^H/w^F=1$. We can write the relevant terms in the left-hand-side of (1) as

$$\frac{\omega\left(\tau^{\sigma-1}-\omega^{-\sigma}\right)+\tau^{\sigma-1}-\omega^{\sigma}}{(\omega+1)}.$$

Taking the derivative of this function with respect to ω, and rearranging we obtain

$$\frac{\partial\left(\frac{\omega\left(\tau^{\sigma-1}-\omega^{-\sigma}\right)+\tau^{\sigma-1}-\omega^{\sigma}}{(\omega+1)}\right)}{\partial\omega}=\frac{\left(1-\omega^{2\sigma}\right)(\sigma-1)+\sigma\omega\left(1-\omega^{2(\sigma-1)}\right)}{(\omega+1)^{2}\omega^{\sigma}}$$

Notice that this derivative is 0 when $\omega=1$, while it is positive when $\omega<1$ and negative when $\omega>1$. Thus $\omega=1$ is the unique global maximum.

Relative Wages in Equilibrium without Multinational Firms

In the main text, we have claimed that if size differences between Home and Foreign are sufficiently large (i.e., $L^{H}/L^{F}>\bar{\lambda}$), then the relative wage at Home will be large enough to ensure that (1) holds and the equilibrium is one with pure exporting (provided that $\tau^{\frac{\sigma-1}{\sigma}}-1>2f_{D}/f_{E}$). To see this, notice that we can write the equation pinning down relative wages $\omega\equiv w^{H}/w^{F}$ in Krugman (1980) as

$$\frac{L^{H}}{L^{F}}\left(\frac{\tau}{\omega}\right)^{\sigma-1}+1=\omega\left(\frac{L^{H}}{L^{F}}+(\tau\omega)^{\sigma-1}\right), \tag{2}$$

Now straightforward differentiation indicates that

$$\frac{\partial\left(\frac{L^{H}}{L^{F}}\left(\frac{\tau}{\omega}\right)^{\sigma-1}+1-\omega\left(\frac{L^{H}}{L^{F}}+1\left(\tau\omega\right)^{\sigma-1}\right)\right)}{\partial\omega}<0$$

while it is also the case that

$$\frac{\partial\left(\frac{L^{H}}{L^{F}}\left(\frac{\tau}{\omega}\right)^{\sigma-1}+1-\omega\left(\frac{L^{H}}{L^{F}}+1\left(\tau\omega\right)^{\sigma-1}\right)\right)}{\partial\left(L^{H}/L^{F}\right)}>0,$$

as long as $\omega^{\sigma}<\tau^{\sigma-1}$. But note that we can write the equilibrium condition (2) as

$$\omega^{\sigma}(\tau)^{\sigma-1}-1=\frac{L^{H}}{L^{F}}\omega^{1-\sigma}\left(\tau^{\sigma-1}-\omega^{\sigma}\right),$$

and thus for the right-hand-side to be positive, indeed $\omega^{\sigma}<\tau^{\sigma-1}$ is required. This proves that not only is the wage higher in the larger country, but the relative wage is actually monotonically increasing in relative size (L^{H}/L^{F}) of the larger country (a result not proven in Krugman, 1980).

From this last displayed equation, we see also that as $L^{H}/L^{F}\rightarrow\infty$, it must be the case that $\tau^{\sigma-1}-\omega^{\sigma}\rightarrow 0$ and thus $\omega\rightarrow\tau^{(\sigma-1)/\sigma}$. Plugging this value in the left-hand-side of condition (1) reduces to

$$\tau^{(\sigma-1)/\sigma}-1<\frac{2f_{D}}{f_{E}},$$

and thus as long as this inequality holds, the equilibrium features exporting for a sufficiently large relative size of Home, as stated in footnote 16 of the main text. When instead $\tau^{\frac{\sigma-1}{\sigma}}-1>2f_{D}/f_{E}$, it follows that the equilibrium features some form of MNE activity *for all* $L^{H}/L^{F}>0$.

We next briefly sketch the equilibrium conditions for alternative candidate equilibria with MNE activity and we next assess whether we can rule out the existence of some of those equilibria.

Equilibrium with Pure MNE Activity (No Exporting)

Consider first an equilibrium without exporting firms. Notice that if there is no trade, multinationals need to break even in each market, which implies

$$\begin{aligned}\frac{1}{\sigma}\left(\frac{\sigma w^H}{\varphi(\sigma-1)}q^H\right) &= \frac{1}{2}f_E w^H + f_D w^H \\ \frac{1}{\sigma}\left(\frac{\sigma w^F}{\varphi(\sigma-1)}q^F\right) &= \frac{1}{2}f_E w^F + f_D w^F\end{aligned}$$

and thus,

$$q^H = q^F = (\sigma-1)\varphi\left(\frac{1}{2}f_E + f_D\right).$$

Nevertheless, this is only consistent with the labor-markets conditions

$$\begin{aligned}m\left(\frac{1}{2}f_E + f_D\right) + m\frac{q^H}{\varphi} &= L^H \\ m\left(\frac{1}{2}f_E + f_D\right) + m\frac{q^F}{\varphi} &= L^F\end{aligned}$$

whenever $L^H = L^F$ (m denotes the measure of multinational firms). In sum, for $L^H > L^F$ any equilibrium must feature a positive mass of exporters.

Equilibrium with MNEs and Exporters in Both Countries

As shown above, an equilibrium in which multinationals and Home and Foreign exporters all break even can only exist if condition (1) holds with equality or

$$\frac{\omega\left(\tau^{\sigma-1} - \omega^{-\sigma}\right) + \tau^{\sigma-1} - \omega^{\sigma}}{(\omega+1)\left(\tau^{\sigma-1}-1\right)}\frac{f_D + f_E}{f_D + \frac{1}{2}f_E} = \frac{\tau^{\sigma-1}+1}{\tau^{\sigma-1}}, \tag{3}$$

where remember that $\omega \equiv w^H/w^F$. It is clear that this condition pins down the relative wage ω as a function of parameters independently of the relative size of the two countries L^H/L^F.

Of course, for this equilibrium to exist, it is necessary to find a positive measure of multinational firms $m > 0$ and positive measures of Home and Foreign exporters ($n^H > 0$ and $n^F > 0$, respectively) consistent with labor-market clearing in each country. Following standard derivations in CES-demand models, these labor-market conditions can be written as

$$m\left(\frac{1}{2}f_E + f_D\right) + m\frac{(\sigma-1)}{\sigma}\frac{L^H}{m + n^H + n^F\tau^{1-\sigma}\omega^{\sigma-1}} + n^H\sigma\left(f_E + f_D\right) = L^H \tag{4}$$

$$m\left(\frac{1}{2}f_E + f_D\right) + m\frac{(\sigma-1)}{\sigma}\frac{L^F}{m + n^F + n^H\tau^{1-\sigma}\omega^{1-\sigma}} + n^F\sigma\left(f_E + f_D\right) = L^F \tag{5}$$

Finally, we need only impose the free-entry condition for one type of firm, for instance, multinational firms

$$\frac{1}{\sigma}\left(\frac{\omega L^H}{m + n^H + n^F\tau^{1-\sigma}\omega^{\sigma-1}}\right) + \frac{1}{\sigma}\left(\frac{L^F}{m + n^F + n^H\tau^{1-\sigma}\omega^{1-\sigma}}\right) = (\omega+1)\left(f_D + \frac{1}{2}f_E\right) \tag{6}$$

In sum, m, n^H and n^F are jointly determined by equations (4) through (6), with ω being determined by (3). We just need to make sure that L^H and L^F are such that an equilibrium with $m > 0$, $n^H > 0$ and $n^F > 0$ exists. But it is easy to construct numerical examples in which such an equilibrium exists.

Equilibrium with MNEs and Exporters only in "the Large" Home

This type of equilbrium is identical to the one above except for the fact that it sets $n^F = 0$, while equation (3) does not apply any more since it was derived assuming that Foreign exporters break even. In sum, we are left with three equations – (4) through (6) with $n^F = 0$ – pinning down m, n^H and ω. Again, it is straightforward to construct numerical examples in which such an equilibrium exists and they appear to exist for small differences in relative size, or L^H/L^F close to one.

Equilibrium with MNEs and Exporters only in "the Small" Foreign

This type of equilbrium is analogous to the one above except for the fact that it sets $n^H = 0$, while equation (3) does not apply any more since it was derived assuming that Home exporters break even. We are thus left with three equations – (4) through (6) with $n^H = 0$ – pinning down m, n^F and ω. We have been unable to generate a numerical example in which this equilibrium exists.

A.2 Variant of the Feenstra and Hanson (1996) model in Section 5.2

Here we show that in the variant of the Feenstra and Hanson (1996) model we developed in section 5.2 an increase in the range of inputs offshored to Foreign increases wage inequality in Foreign. The fact that such a shift increases wage inequality at Home can be shown similarly (in fact, it is much simpler to show).

In the absence of factor price equalization, the North will specialize in all task with $s > s^*$, while the unskilled-labor abundant South will specialize in the stages $s \leq s^*$. Furthermore, the outside good uses only unskilled labor, so it will only be produced in the South (since $w^F < w^H$).

The factor- market clearing conditions in the South are:

$$n\left(\int_0^{s^*} a_K(s)\, x^F(s)\, ds + f\frac{\partial c_1\left(w^H, r^H, w^F, r^F\right)}{\partial r^F}\right) = K^F \tag{7}$$

$$z a_L(z) + n\left(\int_0^{s^*} a_L(s)\, x^F(s)\, ds + f\frac{\partial c_1\left(w^H, r^H, w^F, r^F\right)}{\partial w^F}\right) = L^F \tag{8}$$

where n is the number of final-good producers, $z a_L(z)$ is the demand for unskilled workers in the outside sector and the cost function associated with the final good is

$$c_1\left(w^H, r^H, w^F, r^F\right) = \varkappa \exp\left(\int_0^{s^*} \alpha(s) \ln\left[a_K(s)\, r^F + a_L(s)\, w^F\right] ds + \int_{s^*}^{1} \alpha(s) \ln\left[a_K(s)\, r^H + a_L(s)\, w^H\right] ds\right),$$

where $\varkappa > 0$ is a constant. Differentiating this cost function, we obtain

$$\frac{\partial c_1\left(w^H, r^H, w^F, r^F\right)}{\partial r^F} = c_1\left(w^H, r^H, w^F, r^F\right)\int_0^{s^*} \frac{\alpha(s)\, a_K(s)}{a_K(s)\, r^F + a_L(s)\, w^F} ds; \tag{9}$$

$$\frac{\partial c_1\left(w^H, r^H, w^F, r^F\right)}{\partial w^F} = c_1\left(w^H, r^H, w^F, r^F\right)\int_0^{s^*} \frac{\alpha(s)\, a_L(s)}{a_K(s)\, r^F + a_L(s)\, w^F} ds. \tag{10}$$

Now next that profit maximization and free entry on the part of final-good producers necessarily implies

$$\frac{1}{\sigma} p_1 q_1 = f c_1\left(w^H, r^H, w^F, r^F\right) \tag{11}$$

while input choices must satisfy

$$x^F(s)\left(a_K(s)\,r^F + a_L(s)\,w^F\right) = \alpha(s)\,\frac{\sigma-1}{\sigma}p_1 q_1. \tag{12}$$

Finally, note that from demand, we have that if E is total world spending, then

$$z = \frac{\beta_z E}{a_L(z)\,w^F} \tag{13}$$

$$np_1 q_1 = \beta_1 E \tag{14}$$

Now plugging equations (9) through (14) into (7) and (8) yields

$$\begin{aligned}
\beta_1 E\int_0^{s^*}\frac{a_K(s)\,\alpha(s)}{a_K(s)\,r^F + a_L(s)\,w^F}ds &= K^F; \\
\frac{\beta_z E}{w^F} + \beta_1 E\left(\int_0^{s^*}\frac{a_L(s)\,\alpha(s)}{a_K(s)\,r^F + a_L(s)\,w^F}ds\right) &= L^F.
\end{aligned}$$

Taking the ratio of these two conditions and defining the Foreign wage premium as $\rho^F \equiv r^F/w^F$, we have

$$\frac{\beta_1\left(\int_0^{s^*}\frac{\alpha(s)a_K(s)}{a_K(s)\rho^F + a_L(s)}ds\right)}{\beta_z + \beta_1\left(\int_0^{s^*}\frac{\alpha(s)a_L(s)}{a_K(s)\rho^F + a_L(s)}ds\right)} = \frac{K^F}{L^F}. \tag{15}$$

This expression is analogous to that in Feenstra and Hanson (1996) except for the term β_z in the denominator (theirs is a one-sector model).

Differentiating (15) with respect to s^* we have

$$\frac{\alpha(s^*)\,\beta_1}{\beta_z + \beta_1\left(\int_0^{s^*}\frac{\alpha(s)a_L(s)}{a_K(s)\rho^F + a_L(s)}ds\right)}\left(\frac{a_K(s^*)}{a_K(s^*)\,\rho^F + a_L(s^*)} - \frac{a_L(s^*)}{a_K(s^*)\,\rho^F + a_L(s^*)}\frac{K^F}{L^F}\right) > 0,$$

where the sign follows from the fact that the marginal input s^* must feature a higher skill intensity $(a_K(s^*)/a_L(s^*))$ than the average skill intensity in Foreign (i.e., K^F/L^F).

Consider next the derivative of the left-hand-side of (15) with respect to ρ^F. Feenstra and Hanson (1996) show that $\int_0^{s^*}\frac{\alpha(s)a_K(s)}{(a_K(s)\rho^F + a_L(s))}ds/\int_0^{s^*}\frac{\alpha(s)a_L(s)}{(a_K(s)\rho^F + a_L(s))}$ is necessarily decreasing in ρ^F (see their Lemma 6.1). Together with the fact that $\int_0^{s^*}\frac{\alpha(s)a_L(s)}{a_K(s)\rho^F + a_L(s)}$ is itself decreasing in ρ^F, this necessarily implies that the relative demand for skilled workers (the left-hand-side of (15)) is decreasing in the wage premium ρ^F, an intuitive result.

The combination of these two partial derivatives implies, by the implicit function theorem, that any shock that increases s^* without impacting (15) directly, such as a proportional increase in K^F and L^F that K^F/L^F unchanged, will necessarily lead to an increase in Foreign wage inequality (ρ^F).

A.3 Transaction-cost Model with Hold-Up Inefficiencies in Section 7.1.B

We claimed in the main text that the efficiency of outsourcing as measured by the term

$$\Gamma_O = \left(\frac{\sigma - (\sigma - 1)\left(1 - \frac{1}{2}\phi\right)(1 - \eta)}{\sigma - (\sigma - 1)(1 - \eta)} \right)^{\sigma - (\sigma - 1)(1 - \eta)} \left(1 - \frac{1}{2}\phi\right)^{(1-\eta)(\sigma - 1)} < 1$$

is decreasing in specificity ϕ and increasing in headquarter intensity η. The first result follows directly from:

$$\frac{\partial \ln \Gamma_O}{\partial \phi} = -\frac{1}{2} \frac{\sigma(\sigma - 1)\frac{1}{2}\phi}{\left(1 - \frac{1}{2}\phi\right)} \frac{1 - \eta}{\left(\sigma - (\sigma - 1)\left(1 - \frac{1}{2}\phi\right)(1 - \eta)\right)} < 0.$$

As for the second result, note first that

$$\frac{\partial^2 \ln \Gamma_O}{\partial \eta^2} = -\sigma^2 \left(\frac{1}{2}\phi\right)^2 \frac{(\sigma - 1)^2}{(1 + (\sigma - 1)\eta)\left(\left(\sigma - (\sigma - 1)\left(1 - \frac{1}{2}\phi\right)(1 - \eta)\right)\right)^2} < 0$$

and thus $\frac{\partial \ln \Gamma_O}{\partial \eta}$ is no lower than that same derivative evaluated at $\eta = 0$. We can also show that

$$\frac{\partial^2 \ln \Gamma_O}{\partial \eta \partial \phi} = -\sigma^2 \frac{1}{2}\phi \frac{\sigma - 1}{(\phi - 2)\left(\left(\sigma - (\sigma - 1)\left(1 - \frac{1}{2}\phi\right)(1 - \eta)\right)\right)^2} < 0,$$

and thus $\frac{\partial \ln \Gamma_O}{\partial \eta}$ is no lower than that same derivative evaluated at $\phi = 0$.

Finally, when evaluated at $\eta = \phi = 0$, it is easily verified that $\frac{\partial \ln \Gamma_O}{\partial \eta} = 0$ from which we can conclude that $\frac{\partial \ln \Gamma_O}{\partial \eta} > 0$ for $\eta > 0$ or $\phi > 0$, as stated in the main text.

A.4 Property-Rights Model in Section 7.2

We claimed in the main text that the relative profitability of outsourcing versus integration as measured by the ratio (see eq. (36))

$$\frac{\Gamma_O}{\Gamma_V} = \left(\frac{\sigma - (\sigma - 1)(1 - \beta_O)(1 - \eta)}{\sigma - (\sigma - 1)(1 - \beta_V)(1 - \eta)} \right)^{\sigma - (\sigma - 1)(1 - \eta)} \left(\frac{1 - \beta_O}{1 - \beta_V} \right)^{(1-\eta)(\sigma - 1)},$$

was decreasing in headquarter intensity η. This can be proved via cumbersome differentiation, but it suffices to show that it is a particular case of the more general results in Antràs and Helpman (2008). In particular, equation (36) corresponds to the case in Antràs and Helpman (2008) in which headquarters are fully contractible (or $\mu_h = 1$ in their notation), while manufacturing of components is fully noncontractible (or $\mu_m = 0$ in their notation). For general $\mu_h \in [0, 1]$ and $\mu_m \in [0, 1]$, Antràs and Helpman (2008) show that Γ_O / Γ_V is decreasing in headquarter intensity, so the same must be true in this particular case.

In this same section, we later claimed that, instead of using the share of offshoring firms engaged in FDI as a measure of the relative prevalence of FDI versus foreign outsourcing, we could have instead used the share of imports of manufacturing inputs that are transacted within multinational firrm boundaries. To see this, let us first compute the volume of manufacturing inputs produced in foreign insourcing and foreign outsourcing relationships. These are given by a fraction $\frac{(\sigma - 1)}{\sigma}(1 - \beta_O)(1 - \eta)$ of revenues in an outsourcing relationship and a fraction $\frac{(\sigma - 1)}{\sigma}(1 - \beta_V)(1 - \eta)$ in a vertical FDI relationship. Furthermore, as is well-known revenues are σ times higher than operating profits, so from equations (32) and (35) in the main text, we have that

$$\tau w^S m_O = \frac{(\sigma - 1)}{\sigma}(1 - \beta_O)(1 - \eta)\left(B^H + B^F\right)\left(\left(w^N\right)^\eta \left(\tau w^S\right)^{1-\eta}\right)^{1-\sigma} \lambda^{\sigma - 1} \Gamma_O$$

and

$$\tau w^S m_V = \frac{(\sigma-1)}{\sigma}(1-\beta_V)(1-\eta)\left(B^H+B^F\right)\left(\left(w^N\right)^\eta\left(\tau w^S\right)^{1-\eta}\right)^{1-\sigma}\Gamma_V.$$

Integrating over all firms choosing one strategy or the other and taking the ratio, we have that the share of imports of manufacturing inputs that are transacted within multinational firm boundaries is

$$Sh_{if} = \left[\frac{\int_{\varphi^D}^{\varphi^I}(\sigma-1)(1-\beta_O)(1-\eta)\left(B^H+B^F\right)\left(\left(w^N\right)^\eta\left(\tau w^S\right)^{1-\eta}\right)^{1-\sigma}\lambda^{\sigma-1}\Gamma_O\varphi^{\sigma-1}dG(\varphi)}{\int_{\varphi^I}^{\infty}(\sigma-1)(1-\beta_V)(1-\eta)\left(B^H+B^F\right)\left(\left(w^N\right)^\eta\left(\tau w^S\right)^{1-\eta}\right)^{1-\sigma}\Gamma_V\varphi^{\sigma-1}dG(\varphi)}+1\right]^{-1},$$

which, using the formula for the Pareto distribution and plugging the threshold values φ^D and φ^I delivers

$$Sh_{if} = \left[\frac{(1-\beta_O)\lambda^{\sigma-1}\Gamma_O}{(1-\beta_V)\Gamma_V}\left(\frac{f_{IV}-f_{IO}}{f_{IO}-f_{DV}}\frac{\lambda^{\sigma-1}\Gamma_O/\Gamma_V-\left(\frac{w_N}{\tau w_S}\right)^{-(1-\eta)(\sigma-1)}}{1-\lambda^{\sigma-1}\Gamma_O/\Gamma_V}\right)^{\frac{\kappa}{\sigma-1}-1}+1\right]^{-1}.$$

This expression is more cumbersome than equation (37) in the main text but it continues to be decreasing in $\lambda^{\sigma-1}\Gamma_O/\Gamma_V$, $w_N/\tau w_S$ and κ, from which the main comparative statics in the main text were derived.

We have assumed that imported inputs are valued at marginal cost consistently with the notion that the final-good producer captures all the surplus ex-ante via a lump-sum transfer. It is straightforward to show, however, that even if we were to relate the volume of inputs to the ex-post payoff obtained by suppliers, the same comparative statics would continue to apply since those payments would still be proportional to sale revenue.

B Data Appendix: Data Sources for Tables 3-5

B.1 Table 3

This section describes the data used to generate the coefficient estimates provided in Table 3 of the text. Variable names as they appear in Table 3 are shown in parentheses.

Affiliate Sales (AS): For 1989 and 2009, affiliate sales data refers to the aggregate sales by U.S. affiliates by host country and by main-line-of-business to customers located in the host country market. For robustness checks, the affiliate sales data are corrected for the fact that some affiliates import goods from the United States. This netting was done by multiplying local affiliate sales by one minus the ratio of aggregate affiliate imports from the United States to the aggregate total sales of the affiliates where aggregation is by host country and by main-line-of-business of the affiliate. To access this data, a research must become an unpaid sworn employee of the BEA.

U.S. Exports (Exports): For 2009, U.S. export data was downloaded from the US Census Bureau Related-Party Trade Database (url: http://sasweb.ssd.census.gov/relatedparty/) from NAICS classifications. The data was then aggregated to BEA NAICS-based industrial classifications. For 1989, U.S. export data was downloaded from the website of Peter Schott (url: http://faculty.som.yale.edu/peterschott/sub_international.htm). See Schott (2010) for details.

Freight Costs (Freight): Freight costs are calculated using following Brainard (1997) using U.S. import data. For year t and industry i, freight costs are measured as

$$\ln\left(\frac{CIF_{t\,i}}{FOB_{t,i}}\right),$$

where $CIF_{t\,i}$ is the customs value of U.S. imports plus freight and insurance charges for year t and industry i and $FOB_{t,i}$ is the freight on board value of U.S. imports in year t and industry i. The data were downloaded from Peter Schott's website. See Schott (2010) for further documentation. Data for 2005 were used for the 2009 regressions. Data for 1989 were used for the 1989 regression. For both years, some aggregation over industries was necessary to BEA classifications. Aggregation involved only simple summations over the raw data.

Tariff Levels (Tariffs): Tariff data are applied tariffs from the World Integrated Trade Solution (WITS) database maintained by the World Bank. The data was downloaded (url: http://wits.worldbank.org/wits/) at the NAICS 4-digit level and then concorded into the more aggregate BEA naics-based system. When aggregation was necessary (such as when the BEA industry classification was at the 3 rather than 4 digit level), the simple average of the less aggregated data were used. For 1989, the data was downloaded using SIC based industry classifications to ease concordance to BEA SIC-based industrial classifications. To avoid dropping observations where tariffs are zero (due to the fact that all data enter into the regressions in logarithms), one was added to each observation.

Endowment Differences: Real GDP per worker in 2005 dollars **(GDP/POP)** was downloaded from the Penn World Tables, V 7.1 (url: https://pwt.sas.upenn.edu/php_site/pwt71/pwt71_form_test.php), where the variable name in that dataset is *rgdpwok*. It is calculated as

$$GDP/POP_{i,t} = \ln(|rgdpwok_{US,t} - rgdpwok_{i,t}|),\ t \in \{1989, 2009\}$$

The measure of human capital endowment differences across countries **(School)** is derived from the average years of education downloaded from the Barro-Lee dataset (url: http://www.barrolee.com/data/dataexp.htm). If $EDyr_i$ is the average years of education in country i for 2005, the variable used in the regressions is defined as

$$School_i = \ln(|EDyr_{US} - EDyr_i|)$$

The capital to labor ratio **(KL)** is taken from Penn World Tables V7.1 for the year 2008. The variable is calculated as

$$KL_i = \ln(|KAPW_{US} - KAPW_i|),$$

where $KAPW_i$ is the capital to worker ratio for 2005.

Market Size: Market size was measured as the logarithm of real GDP **(GDP).** This data is constructed from the Penn World Tables, V 7.1, at the natural logarithm of the product of real GDP per capita, $CGDP$, and population, POP.

Scale Economies: Plant scale economies **(PlantSC)** are measured as the average number of production worker employees per establishments in the United States. Corporate Scale Economies (**CorpSC**) was measured as the average number of non-production workers per U.S. based firm. In both cases, data for the 2009 regressions are from the Census of Manufacturing, 2007. For the 1989 regression, the data is from the Census of Manufacturing 1992.

The following are control variables that were included in the regressions but their coefficients were suppressed in Table 3.

Investment Protection: Index of protection of foreign investors from expropriation or discriminatory policies by country that is based on surveys of large corporations. Source: *World Competitiveness Report* (1996)

Trade Openness*:* Index of openness to international trade by country that is based on surveys of large corporations. Source: *World Competitiveness Report* (1996)

Political Stability: Variance in political stability across country was measured using an index downloaded from the *International Country Risk Guide* (url: http://www.prsgroup.com/countrydata.aspx).

B.2 Table 4

With the exception of the following variables all of the variables used to obtain the coefficient estimates in Table 4 are the same as those used in the 2009 regressions that generated Table 3.

Skill Intensity (Skillint): The skill intensity of an industry is measured as in Yeaple (2003*a*). It is the cost share of non-production workers, which is calculated as wage bill of non-production workers by industry (total wages - production worker wages) divided by total value-added by industry. The data were obtained from the Annual Survey of Manufacturers data for the year 2009.

Skill Endowment (Skillend): The skill endowment of a country was measured using the human capital per worker variable calculated by Hall and Jones (1999). These data can be downloaded from Chad Jones' website at http://www.stanford.edu/~chadj/datasets.html.

B.3 Table 5

Intrafirm import share: From the U.S. Census Bureau's Related Party Trade Database, for the years 2000-2011 (available at http://sasweb.ssd.census.gov/relatedparty/). For columns I through V, we use the data at the original six-digit NAICS industry level. For the "Buyer" regressions in columns VI through VIII we follow Antràs and Chor (2012) in mapping these NAICS codes to six-digit IO2002 industry codes using the correspondence provided by the Bureau Economic Analysis (BEA) as a supplement to the 2002 U.S. Input-Output (I-O) Tables. The share of intrafirm imports was calculated for each industry-year or country-industry-year as: *(Related Trade)/(Related Trade + Non-Related Trade).*

R&D intensity: From Nunn and Trefler (2011), who calculated R&D expenditures to total sales using the sample of U.S. firms in the Orbis dataset. We added 0.001 to R&D intensity before taking logarithms to avoid throwing away a large number of observations with zero R&D outlays, while we dropped observations for which R&D expenditures exceeded sales. The R&D intensity for each NAICS industry in columns I-V was then calculated as the weighted average value of $\log(0.001 + R\&D/Sales)$ over the years 2000-2006. Following Antràs and Chor (2012), the R&D intensity for the average buyer in columns VI-VIII was calculated by taking a weighted average over the years 2000-2005 of the R&D intensity of the industries that purchase the input in question, with weights equal to these input purchase values as reported in the 2002 U.S. I-O Tables.

Skill Intensity: From the NBER-CES Manufacturing Industry Database (Becker and Gray, 2009). Skill intensity is the log of the number of non-production workers divided by total employment. A simple average of the annual values from 2000-2005 was taken to obtain the seller industry measure of skill intensity in columns I-V. For the buyer skill intensity measure in columns VI-VIII we followed the same procedure as for the R&D intensity measure.

Capital Intensity: All the capital intensity measures (Buildings, Equipment, Autos, Computers, and Other Equipment, all divided by total employment) were taken from the Annual Survey of Manufactures (url http://www.census.gov/manufacturing/asm/), where they are available at the NAICS level (but at a slightly less disaggregated level than the skill intensity measure taken from the NBER-CES data). A simple average of the annual values from 2002-2010 was taken to obtain the seller industry measures of capital intensity in columns I-V. For the buyer capital intensity measures in columns VI-VIII we followed the same procedure as for the R&D intensity measure.

Contractibility: Computed as in Antràs and Chor (2012) from the 2002 U.S. I-O Tables, following the methodology of Nunn (2007). For each IO2002 industry, we first calculated the fraction of HS10 constituent codes classified by Rauch (1999) as neither reference-priced nor traded on an organized exchange, under Rauch's "liberal" classification. (The original Rauch classification was for SITC Rev. 2 products; these were associated with HS10 codes using a mapping derived from U.S. imports in Feenstra et al. (2002).) We took one minus this value as a measure of the own contractibility of each IO2002 industry. The average buyer contractibility was then calculated using the same procedure described for computing the average buyer R&D intensity.

Dispersion: From Nunn and Trefler (2008), who constructed dispersion for each HS6 code as the standard deviation of log exports for its HS10 sub-codes across U.S. port locations and destination countries in the year 2000, from U.S. Department of Commerce data. The dispersion for the average buyer was then calculated using the same procedure described for the R&D intensity measure.

Freight Costs and Tariffs: Freight costs data were downloaded at the NAICS level from Peter Schott's website (see Schott, 2010, for further documentation). These were concorded to IO2002 industries as described above for the share of intrafirm trade. Tariff data are applied tariffs from the World Integrated Trade Solution (WITS) database maintained by the World Bank. The data was downloaded (url: http://wits.worldbank.org/wits/). Tariffs were concorded directly from HS 6-digit level to IO2002 level (rather than HS to NAICS then to IO2002).

References (not listed in main text)

Becker, Randy A., and Wayne B. Gray, (2009), "NBER-CES Manufacturing Industry Database (1958-2005)" available at http://www.nber.org/data/nbprod2005.html.

Feenstra, Robert C., John Romalis, Peter K. Schott, (2002), "U.S. Imports, Exports and Tariff Data, 1989-2001," *NBER Working Paper* 9387.

Hall, Robert E. and Charles I. Jones (1999), "Why Do Some Countries Produce So Much More Output per Worker than Others?" *Quarterly Journal of Economics*, 114:1, pp. 83-116.

Rauch, James E., (1999), "Networks versus Markets in International Trade," *Journal of International Economics* 48(1): 7-35.

Schott, Peter K. (2010), "U.S. Manufacturing Exports and Imports by SIC or NAICS Category and Partner Country, 1972 to 2005," mimeo Yale School of Management, May.