Growth, Size, and Openness: a Quantitative Approach

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1 Introduction: A Puzzle

Aggregate economies of scale are the engine of growth in models with quasi-endogenous research: larger populations are linked to a higher stock of non-rival ideas (see Jones, 1995; Kortum, 1997; Eaton and Kortum, 2001). Thus, growth rates of per capita real output are proportional to population growth rates, $g_y = \varepsilon \cdot g_L$, where the parameter ϵ is the efficiency-size elasticity. One immediate implication of this relationship is that given a value for this elasticity and a measure of the (productive) size of the country, we can predict a country's real income per capita in isolation. A value for ϵ can easily be calculated from the growth rate of output per capita g_y and country's size g_L. Calibrating $g_y = 1\%$ and $g_L = 4.8\%$ entails $\epsilon = 0.21$.[1] One immediate implication of the relationship above is that for given a value of ϵ and a measure of the (productive) size of the country, we can predict a country's real income per capita in isolation. Or, analogously, we can calculate the efficiency size elasticity by simply running a regression of the observed real income per capita on a measure of country's size, using a cross-section of countries. For a set of nineteen OECD countries, the implied elasticity is $\epsilon = 0.084$.[2]

Figure 1 shows real income per capita for country n as a function of our measure of country's size, as implied by the data and the quasi-endogenous growth model.

The implication of an efficiency-size elasticity of 0.21 is that a small country like Belgium, that represents around 3% of total equipped labor for this set of OECD countries, should be

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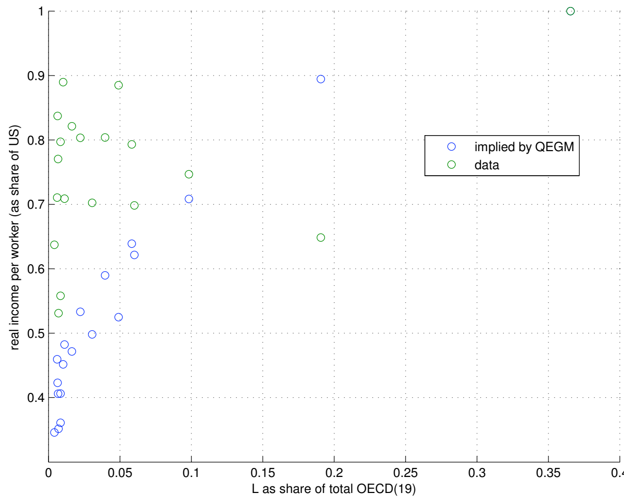
[1] Here g_y is growth rate of real output per worker in the OECD over the last four decades (from Klenow and Rodriguez-Clare, 2005), and g_L is growth rate of R&D employment over the last decades in the top five R&D countries (from Jones, 2002). Other studies find a similar number for this elasticity. Alcala and Ciccone (2004) obtain a efficiency-size elasticity between 1/6 and 1/4.5 controlling also by quality of institutions in a country.

[2] See below for a detailed explanation of the data used.



almost half as rich as the United States (0.45), while in the data Belgium real income per worker represents 0.9 of U.S.'s.

But, of course, the differences between these two elasticities are given, among others, by the fact that countries are not in isolation; they gain from interacting with the rest of the world through various channels. Here, we focus on gains from trade, multinational production (MP), and direct diffusion of ideas. The main problem is that while trade and MP are directly observable, diffusion is not. We present an indirect approach to identify diffusion in the data. We ask how much diffusion is needed, once we have international trade and MP, to reconcile the efficiency-size elasticity observed in the data and the one implied by the quasi-endogenous growth model.

We start by presenting a simple quasi-endogenous growth model based on Kortum (1997), and Eaton and Kortum (2001). Then, we extend Eaton and Kortum's (2002) model of trade to incorporate MP and diffusion of ideas, and we embedded in the growth model. We based our analysis in results derived in Ramondo and Rodriguez-Clare (2009). The model is Ricardian with a continuum of tradable intermediate goods and non-tradable final goods, produced under constant-returns-to-scale. We adopt the probabilistic representation of technologies as first introduced by Eaton and Kortum (2002), extended to incorporate MP and diffusion. We embed the model into a general equilibrium framework similar to the one in Alvarez and Lucas (2007).

2 A Simple Quasi-Endogenous Growth Model

Consider a closed economy with L units of labor. A representative agent consumes a continuum of final goods indexed by $u \in [0, 1]$ in quantities $q_f(u)$. Preferences over final goods are CES with elasticity $\sigma_f > 0$. Final goods are produced with labor and a continuum of intermediate goods indexed by $v \in [0, 1]$. Formally, intermediate goods in quantities $q_g(v)$ are aggregated into a *composite intermediate good* via a CES production function with elasticity $\sigma_g > 0$. We denote the total quantity produced of this composite intermediate good as Q. The composite intermediate good and labor are used to produce final goods via Cobb-Douglas technologies with varying productivity levels,

$$q_f(u) = z_f(u) L_f(u)^{\alpha} Q_f(u)^{1-\alpha}. \tag{1}$$

The variables $L_f(u)$ and $Q_f(u)$ denote the quantity of labor and the composite intermediate good used in the production of final good u, respectively, and $z_f(u)$ is a productivity parameter. Similarly, intermediate goods are produced according to

$$q_g(v) = z_g(v) L_g(v)^{\beta} Q_g(v)^{1-\beta}. \tag{2}$$

The productivity parameters $z_f(u)$ and $z_g(v)$ are random variables coming from the following exogenous research process. Research is modeled as the creation of ideas. In particular, we assume that there is an instantaneous (and constant) rate of arrival ϕ of ideas per person. Ideas are specific to goods, and the good to which an idea applies can be an intermediate good or a final good with equal probability. If the idea applies to an intermediate (final) good the identity of the good is drawn from a uniform distribution in $v \in [0,1]$ ($u \in [0,1]$). This implies that at time t there is a probability $\phi L(t)$ of drawing an idea for any particular (intermediate or final) good. The arrival of ideas is then a Poisson process with rate function $\phi L(t)$, so the number of ideas that have arrived for a particular good by time t is distributed Poisson with rate $T(t)$, where $T(t) \equiv \int_0^t \phi L(t) ds$,

Ideas have also associated a productivity or quality q, drawn from a Pareto distribution with parameter θ. The economy's technology is determined by the best idea available for the production of each good. That is, letting Ω denote the set of all q's associated with ideas existing at a certain point in time in a country, then the technology frontier is $z = \max\{q \in \Omega\}$, distributed according to a Frèchet distribution with parameters T and θ, $F(z) = \exp\left(-Tz^{-\theta}\right)$. Higher T means more ideas, and thus, a better technology frontier (higher z). Further, assume that $L_i(t)$ grows at the constant rate g_L. Then, in steady state $T(t) = \phi L(t)/g_L$, so that $\dot{T}(t)/T(t) = g_L$.

The characterization of the equilibrium for this closed economy follows closely the analysis in Eaton and Kortum (2002) and Alvarez and Lucas (2007). Suffice it to say here that the equilibrium real wage, or real output per worker, is given by

$$y \equiv \frac{w}{P_f} = \widetilde{\gamma} \cdot T^{\frac{1+\eta}{\theta}}, \tag{3}$$

where $P_f = \left(\int_0^1 p_f(u)^{1-\sigma_f} du\right)^{1/(1-\sigma_f)}$ is the price index for final goods, $\eta \equiv (1-\alpha)/\beta$, and $\widetilde{\gamma}$ is a positive constant.[3]

[3] In a competitive equilibrium, prices of final goods are given by $p_f(u) = c_f/z_f(u)$. The unit cost of the input bundle for final goods is $c_f = Aw^{\alpha} P_g^{1-\alpha}$, with the aggregate price for intermediates $P_g = \left(\int_0^1 p_g(v)^{1-\sigma_g} dv\right)^{1/(1-\sigma_g)}$, $p_g(v) = c_g/z_g(v)$, the unit cost of the input bundle for intermediate goods $c_g = Bw^{\beta} P_g^{1-\beta}$, and A and B are constants that depend on α and β, respectively.

Equation (3) implies that the real wage is increasing at rate

$$g_y = \frac{1+\eta}{\theta} g_T, \tag{4}$$

where $g_T = g_L$.

3 Trade, Multinational Production, and Diffusion

Now consider a set of countries indexed by $i \in \{1, ..., I\}$ with preferences and technologies as described above. Country i has L_i units of labor. Each country i has a technology to produce each final good and each intermediate good, at home or abroad. These technologies are described by the vectors $\mathbf{z}_{fi}(u) \equiv \{z_{f1i}(u), ..., z_{fIi}(u)\}$ and $\mathbf{z}_{gi}(v) \equiv \{z_{g1i}(v), ..., z_{gIi}(v)\}$, that are random across goods and countries.

As above, ideas are specific to goods, and the good to which an idea applies can be an intermediate good or a final good with equal probability. But now, each idea in country i is characterized by the vector $\mathbf{q_i} = (q_{1i}, q_{2i}, ..., q_{Ii})$ where q_i is drawn from a multivariate Pareto distribution with parameter θ and zero correlation across draws. The technology frontier for country i is the upper envelope of all the vectors $\mathbf{q}_i$. Hence, the productivity vectors $\mathbf{z}_{fi}(u)$ and $\mathbf{z}_{gi}(v)$ for each good are random variables drawn independently across goods and countries from a multivariate Fréchet distribution with parameter T_i, $\theta > \max\{1, \sigma - 1\}$, and zero correlation across draws,

$$F_i(\mathbf{z}_{si}) = \exp\left(-\sum_l T_i z_{sli}^{-\theta}\right). \tag{5}$$

Further, we assume that the parameter ϕ_i, that captures "research" productivity, varies across countries so that $T_i = \phi_i L_i$. Thus, as for the closed economy , assuming that the growth rate g_L is common across countries, in steady state $T_i(t)$ grows at rate g_L for all i. The real wage in all countries is increasing at the rate g described in equation (4).

Intermediate goods are tradable but final goods are not. Trade is subject to iceberg-type costs: $d_{nl} \geq 1$ units of any good must be shipped from country l for one unit to arrive in country n.[4]

We introduce multinational production (MP) and diffusion of ideas in a similar way as in Ramondo and Rodriguez-Clare (2009). There are national and global ideas that can be applied to the production of an intermediate good (final good), at home or abroad. These random vectors are denoted by $\mathbf{z_{si}^N} = (z_{s1i}^N, ..., z_{sIi}^N)$ and $\mathbf{z_{si}^G} = (z_{s1i}^G, ..., z_{sIi}^G)$, respectively, for $s = g, f$, and they are drawn (independently across goods, countries, and also of other technologies) from a multivariate Frèchet distribution with (common) parameter θ, and parameters T_i^N and T_i^G, for national and global technologies, respectively.

At any point in time the share of global ideas is κ, $T_i^G/T_i^N = \kappa$ for all i. This parameter κ is related to the speed of diffusion of ideas as follows. Assume that ideas are born as national and then diffuse at a rate ι so that $\dot{T}_i^G = \iota T_i^N$, or equivalently $\dot{T}_i^G/T_i^G = \iota T_i^N/T_i^G$. Assuming

[4] We assume that $d_{nn} = 1$ for all n and the triangle inequality holds: $d_{nl} \leq d_{nj} d_{jl}$ for all n, l, j.

that $\dot{T}_i^G/T_i^G = \dot{T}_i^N/T_i^N = g_L$, we have that $T_i^G/T_i^N = \iota/g_L$ where $\kappa \equiv \iota/g_L$. The expected life of an idea as national is $1/\iota$; if this is twenty years, $\iota = 1/20$, and with $g_L = 0.048$, this implies that $T_{li}^G/T_{li}^N = (1/20)/0.048 = 1.042$, whereas if the expected life is fifty years then $T_i^G/T_i^N = (1/50)/0.048 = 0.42$.

The difference between national and global ideas is the following. National ideas from country i can be used in a different country l incurring an iceberg-type efficiency loss of $h_{sli} \geq 1$ (with $h_{sii} = 1$). Then, we say that there is MP by i in l, and the unit cost of an intermediate good v incurred by i in l is $c_{gl}h_{gli}/z_{gli}(v)$ (and $c_{fl}h_{fli}/z_{fli}(u)$ for a final good u). Global ideas from country i can also be used for production abroad but at no efficiency cost; in this case we say that ideas diffused. Finally, while trade and MP are both feasible for intermediate goods, only MP is feasible for final (non-tradable) goods.

The equilibrium analysis for the open economy follows closely the one presented in Ramondo and Rodriguez-Clare (2009).

3.1 Gains

In the framework presented above, we can compute the gains from trade (GT), the gains from MP (GMP), and the gains from diffusion (GD), for each country. In particular, the gains from trade for a country n are computed as changes in the real wage w_n/P_{fn} from a counterfactual scenario with no trade to a situation with all three international channels. Importantly, with uncorrelated productivity draws for a given country n, across possible locations of production (i.e. the vector $\mathbf{z_{sn}}$ has uncorrelated elements, for $s = g, f$), we can show that the gains from trade are independent from the presence of the other two flows. Thus, the gains of moving from isolation (no trade, no MP, and no diffusion) to a situation with only trade are the same gains as the ones computed under the presence of the other flows, and consequently they are the same as the gains computed in models with only trade. Analogous argument can be made for the gains from diffusion. We compute the gains from MP as the change in the real wage from a situation with no trade, no MP, and no diffusion to a situation with only MP. With uncorrelated productivity draws, these gains are exactly the ones computed from a model with only MP.[5]

Additionally, in the case of uncorrelated productivity draws, it can be shown that the gains of trade and the gains from MP can be written as a function of trade and MP flows, respectively.[6] In particular, let $X_n = \sum_{i \neq n} X_{ni}$ be total imports into country n, and $Z_{gn} = \sum_{i \neq n} Z_{gni}$ be total production of MP by i in n, in the intermediate good sector. Let Y_{gn}, $s = g$, denote expenditure in intermediate goods in country n, and Y_n total expenditure in final goods (this is total income for country n equal to total labor income, w_nL_n).[7] The gains from trade are

$$GT_n = \left(1 - \frac{X_n}{Y_{gn}}\right)^{-\eta/\theta}, \tag{6}$$

[5]We show in our previous work (Ramondo and Rodriguez-Clare, 2009) that the gains from MP given trade are different from the gains of going from isolation to only MP. Quantitatively, however, the difference between the two magnitudes is not significant.

[6]See the results in Ramondo and Rodriguez-Clare, 2009.

[7]It can be shown that $Y_{gn} = \eta Y_n$ where $\eta \equiv (1 - \alpha)/\beta$.

while the gains from MP in the intermediate good sector are

$$GMP_{gn} = \left(1 - \frac{Z_{gn}}{Y_{gn}}\right)^{-\eta/\theta}, \tag{7}$$

and in the final good sector

$$GMP_{fn} = \left(1 - \frac{Z_{fn}}{Y_n}\right)^{-1/\theta}. \tag{8}$$

Moreover, $GMP_n = GMP_{gn} \cdot GMP_{fn}$. Finally, the gains from diffusion are easily calculated using the assumption that a share κ of ideas are born as global ideas, $T_n^G/T_n^N = \kappa$. Then,

$$GD_n = \left(\frac{1}{1+\kappa} + \frac{\kappa}{1+\kappa}\frac{\sum_i T_i^N}{T_n^N}\right)^{(1+\eta)/\theta}. \tag{9}$$

Finally, the overall gains from openness are just $GO_n = GT_n \cdot GMP_n \cdot GD_n$.

4 Calibration

We want to calculate the gains from trade, the gains from MP, and the gains from diffusion using the equations above. First, we need data on trade flows from i to n, sales of affiliates from i in n, as share of total expenditure in intermediate goods and final goods, respectively. And second, we need to calibrate the following parameters: θ and the vector $\{T_i^N\}_{i=1}^I$ in the Frèchet distribution; the labor shares in intermediate and final goods, α and β, respectively; and the parameter κ related to the speed of diffusion of global ideas.

We restrict our analysis to the set of nineteen OECD countries.[8] We use STAN data on manufacturing trade flows from country i to country n as the empirical counterpart for trade in intermediates in the model, X_{ni}, normalized by the importer's total expenditure in manufacturing. We use UNCTAD data on the gross value of production for multinational affiliates from i in n as the empirical counterpart of bilateral MP flows in the model, $Z_{ni} \equiv Z_{fni} + Z_{gni}$, normalized by GDP in the host country n. The share of MP in final goods relative to all MP is available for the United States, from the Bureau of Economic Analysis (BEA). We assume that this share applies to the remaining countries so that we can disentangle Z_{fni} and Z_{gni}.[9]

We set the labor share in the intermediate goods' sector, β, to 0.5, and the labor share in the final sector, α, to 0.75, as calibrated by Alvarez and Lucas (2007). This implies $\eta \equiv (1-\alpha)/\beta = 0.5$. The parameter θ is set to 7.2 using equation (4) where $g_y = 1\%$ and $g_L = 4.8\%$.[10] The

[8] Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, United Kingdom, Germany, Greece, Italy, Japan, Netherlands, Norway, New Zealand, Portugal, Sweden, and the United States.

[9] All the data are averages over the period 1990-2002.

[10] Although g_y in our model stands for the growth rate of real wages or real GDP per capita, in the calibration we need to consider the role of physical and human capital accumulation. Thus, we use the growth rate of TFP as a calibration target for g_y from Jones (2002). For g_L we use the growth rate of R&D employment over the last decades in the five top R&D-performing countries (France, West Germany, Japan, the United States and the United Kingdom), for the period 1950-1993, also from Jones (2002).

parameter T_i^N represents the stock of (national) ideas in country i and is proportional to L_i, with $T_i^N/L_i = \phi_i$ different across countries. For L_i, we used a measure of equipped-labor from Klenow and Rodriguez-Clare (2005) that controls both for physical and human capital. The parameter ϕ_i is assumed to vary directly with the share of R&D employment observed in the data.[11]

The calibration of the parameter κ is a crucial part of the quantitative exercise we present below.

5 Reconciling the Puzzle

The dynamic relationship $g_y = \epsilon \cdot g_L$ from the quasi-endogenous growth model in Section 2 implies that real income per worker in country n is given by $y_n = C\,(\phi_n L_n)^{\epsilon}$, where C is a constant set to normalize $y_{US} = 1$. The calibrated version of our model implies that $\epsilon \equiv g_y/g_L = (1+\eta)/\theta = 0.21$.[12] According to this calculation, the real income per worker for a small country like Belgium should be 45%.

We ask: What is the real income per worker under isolation implied by our model if countries were interacting only through MP? only MP and trade? That is, we take the real income per worker as observed in the data and deflate it by the gains from MP, y_n/GMP_n, and the gains from trade and MP, $y_n/(GT_n GMP_n)$, successively, calculated using the calibrated version of model. Once we have the counterfactual income for the two scenarios, we calculate the implied efficiency-size elasticity in each case, and we check whether it matches the one implied by the calibrated version of our growth model of 0.21.

As long as there is a gap between the elasticity implied by the growth model and the one implied by the model with trade and MP, we think that there is room for "diffusion". We use this gap as our quantitative device to conclude for the need of adding diffusion as a third channel through which countries interact. But, how much diffusion do we need? We calibrate the parameter κ targeting precisely the efficiency-size elasticity of 0.21. We proceed as above: we take the real income per worker as observed in the data and deflate it by the gains from openness (trade, MP, and diffusion) as implied by our model, y_n/GO_n, for a given value of κ. We then pick κ such that the efficiency-size elasticity implied by the deflated income matches 0.21.

Table 1 presents the results on the implied efficiency-size elasticity. It turns out that we need a diffusion lag ι of 297 periods that implies $\kappa = (1/\iota)/g_L = 0.07$, or in other words, that 6.55% of the stock of ideas of a country are global.

Table 2 shows the implied real income per capita (relative to U.S.) when we remove MP, MP and trade, and trade, MP and diffusion, successively, by country. With a share of global ideas of 6.55%, the "small country puzzle " is reconciled. A country like Belgium that represents 3% of equipped-labor among the set of OECD countries considered, would have a real income per worker under isolation of 0.45 of U.S.'s as implied by the growth model, while the model where

[11] Source: World Development Indicators, average over the nineties.

[12] Controlling for the effects of trade, institutions, and geography, Alcala and Ciccone (2004) find an elasticity ranging from 1/6 to 1/4.5, a range which encompasses our implied elasticity value.

Efficiency-Size Elasticity (ε) implied by:	Value
Quasi Endogenous Growth Model	0.208
Data	0.084
Model with MP	0.089
Model with Trade and MP	0.0965
Model with Trade, MP, and Diffusion	0.208

Table 1: The Gains from Openness and the Size of Countries: the efficiency-size elasticity.

we remove MP, trade, and diffusion would imply an income for Belgium of 0.5 of U.S.'s.

Finally, figure 1 plots the gains from openness, MP, trade, and diffusion, by country, calculated using the calibrated model where the implied share of global ideas is 6.5%.

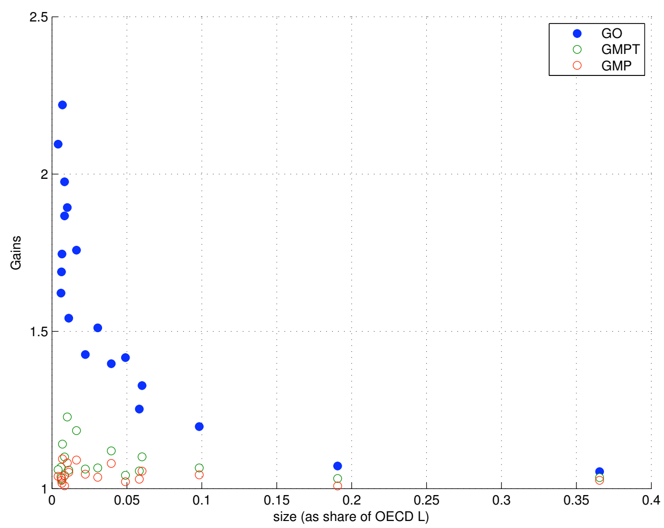


Figure 1: Gains and Size. OECD(19).

6 Concluding Remarks

The gains from openness for a country arise from many possible channels. We focus on trade, multinational production (MP), and direct diffusion of ideas. We show that to reconcile key facts about trade, MP, growth, and size, we need to include diffusion of ideas across countries. The quantitative discipline to include diffusion hinges on the fact that even if a small country

	Size	Real Income per Worker				
	L	y_{data}	y_{data}/GMP	$y_{data}/(GT \cdot GMP)$	y_{data}/GO	T^{ϵ}
Australia	0.06	0.80	0.79	0.78	0.59	0.53
Austria	0.02	0.80	0.79	0.75	0.45	0.41
Belgium	0.03	0.89	0.84	0.75	0.50	0.45
Canada	0.11	0.80	0.76	0.74	0.61	0.59
Denmark	0.02	0.77	0.78	0.78	0.47	0.41
Spain	0.08	0.70	0.70	0.68	0.49	0.50
Finland	0.02	0.71	0.70	0.69	0.46	0.46
France	0.16	0.79	0.79	0.78	0.67	0.64
Great Britain	0.16	0.70	0.68	0.66	0.55	0.62
Germany	0.27	0.75	0.73	0.73	0.66	0.71
Greece	0.02	0.56	0.57	0.55	0.30	0.36
Italy	0.13	0.88	0.89	0.88	0.66	0.52
Japan	0.52	0.65	0.66	0.65	0.64	0.89
Netherlands	0.04	0.82	0.77	0.72	0.49	0.47
Norway	0.02	0.84	0.84	0.84	0.52	0.42
New Zealand	0.01	0.64	0.63	0.62	0.32	0.35
Portugal	0.02	0.53	0.50	0.48	0.25	0.35
Sweden	0.03	0.71	0.69	0.69	0.48	0.48
United States	1	1	1	1	1	1

The implied real income per worker under isolation for the model with: MP is y_n^{data}/GMP_n; trade and MP is $y_n^{data}/(GT_n \times GMP_n)$; trade, MP, and diffusion is y_n^{data}/GO_n. Real income per worker in the growth model is computed as proportional to T_n^{ϵ} where $\epsilon = 0.21$ as implied by the model's calibration, and $T_n = \phi_n L_n$ with L_n = equipped labor from Klenow and Rodriguez-Clare (2005), and ϕ_n = share of R&D employment from WDI, an average over the nineties. The data on income per worker is from Penn World Tables, 6.2 (RGDPW), an average for the nineties.

Table 2: Size, Gains from Openness, and Real Income per Worker.

is closed to trade and MP, the data suggest that this country is much richer than implied by its small size.

References

Alcala, Francisco, and Antonio Ciccone. 2004. "Trade and productivity". *Quarterly Journal of Economics* 119 (2), 613-646.

Alvarez, Fernando, and Robert E. Lucas. 2007. "General Equilibrium Analysis of the Eaton-Kortum Model of International Trade". *Journal of Monetary Economics*. Volume 54, Issue 6.

Eaton, Jonathan, and Samuel Kortum. 2001. "Technology, Trade, and Growth: A Unified Framework". *European Economic Review*, 45, 742-755.

Eaton, Jonathan, and Samuel Kortum. 2002. "Technology, Geography and Trade". *Econometrica*, Vol. 70(5).

Eaton, Jonathan, and Samuel Kortum. 2006. "Innovation, Diffusion, and Trade". *NBER*, Working Paper 12385.

Feenstra, Robert, and Robert Lipsey. 2005. NBER-United Nations Trade Data.

Jones, Charles I. 1995. "R&D-Based Models of Economic Growth". *Journal of Political Economy*, Vol. 103, pp. 759-784.

Jones, Charles I. 2002. "Sources of U.S. Economic Growth in a World of Ideas", *American Economic Review*, Vol. 92, No. 1 (March), 220-239.

Keller, Wolfang. 2004. "International Technology Diffusion". *Journal of Economic Literature* 42: 752-782.

Keller, Wolfang. 2008. "International Trade, Foreign Direct Investment, and Technology Spillovers". Forthcoming in Handbook of Technological Change, edited by Bronwyn Hall and Nathan Rosenberg, North-Holland.

Klenow, Peter, and Andrés Rodríguez-Clare. 2005. "Externalities and Growth". *Handbook of Economic Growth*, Vol. 1A, P. Aghion and S. Durlauf, eds., 817-861 (chapter 11).

Kortum, Samuel. 1997. "Research, Patenting and Technological Change". *Econometrica* 65, 1389-1419.

Ramondo, Natalia, and Andrés Rodríguez-Clare. 2009. "Trade, Multinational Production, and the Gains from Openness". Mimeo, University of Texas-Austin and Penn State University.

Rodríguez-Clare, Andrés. 2007. "Trade, Diffusion, and the Gains from Openness". Mimeo, Penn State University.

Simonovska, Ina, and Michael Waugh. 2009. "The Elasticity of Trade for Developing Nations: Estimates and Evidence ". Mimeo, UC Davis and NYU-Stern.

Waugh, Michael. 2007. "International Trade and Income Differences". Mimeo, NYU-Stern.