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The global diffusion of ideas and its impact on productivity and growth

by Francisco J. Buera, senior economist and economic advisor, and Ezra Oberfield, assistant professor of economics, Princeton University[1]

Economic growth often comes hand in hand with the growth of trade. However, according to quantitative models that rely on standard static mechanisms, the gains from trade are fairly small. This article introduces a model to study the diffusion of ideas across countries as a means of increasing productivity, and provides a quantitative assessment of the role of trade in the transmission of knowledge.

The merit of free trade is a widely debated subject. That said, openness to trading is often associated with economic growth. The experiences of South Korea in the postwar period and the recent performance of China are prominent examples. Recent empirical work using natural experiments that induce larger changes in trade costs for some pairs of countries than others—such as the decline in the cost of shipping goods by air, the closure of the Suez Canal, and the introduction of the steamship[2]—implies large growth effects.[3] Yet, quantitative trade models relying on standard static mechanisms imply fairly small gains from openness and, therefore, cannot account for growth miracles or large growth effects.[4] Recent work has analyzed an alternative mechanism: the impact of openness on the creation and diffusion of best practices across countries.[5]

Openness to trading is often associated with economic growth.

A theory of innovation and diffusion in an interconnected world

In our recent working paper,[6] we model innovation and diffusion as a process involving the combination of new ideas with insights from other industries and countries. Insights occur randomly and result from local interactions among producers. In our theory, openness affects the creation and diffusion of ideas by determining the interactions from which producers draw their insights. Openness affects the set of producers that sell goods within a country, as well as the set of technologies used domestically.

In this context, we provide conditions under which the distribution of productivity among producers within each country converges to a Fréchet distribution,[7] no matter how trade barriers shape individual producers' local interactions. The state of knowledge within a country can be summarized by the level of this distribution, which we call the country's stock of knowledge. Furthermore, we show that the change in a country's stock of knowledge can be characterized in terms of only its trade

shares, its trading partners' stocks of knowledge, and parameters. The model is thus tractable and compatible with the widely used quantitative frameworks that have been useful in studying trade flows in an environment with many asymmetric countries.[8] Consequently, the model both yields qualitative insights and enables us to use actual trade flows to discipline the role of trade and geography in shaping idea flows and growth.

Starting from autarky (closed borders), a country opening itself to trade results in a higher temporary growth rate and a permanently higher level of the stock of knowledge, as producers are exposed to more productive ideas. We separate the gains from trade into static and dynamic components. The static component consists of the gains from increased specialization and comparative advantage, whereas the dynamic component comprises the gains that are made through the flow of ideas.

In an environment in which producers in a country gain insights from those that sell goods to the country, the dynamic gains from reducing trade barriers are qualitatively different from the static gains. The dynamic gains are largest for countries that are relatively closed, whereas the static gains are largest for countries that are already relatively open. For a country with high trade barriers, the marginal imports tend to be made by a foreign producer with high productivity. While the high trade costs imply that the static gains from trade remain fairly small, the insights drawn from these marginal producers tend to be of high quality. In contrast, for a country with low trade barriers, the reduction in trade costs leads to large inframarginal static gains from trade, but the insights drawn from the marginal producers are likely to yield lower productivity and generate lower-quality ideas.

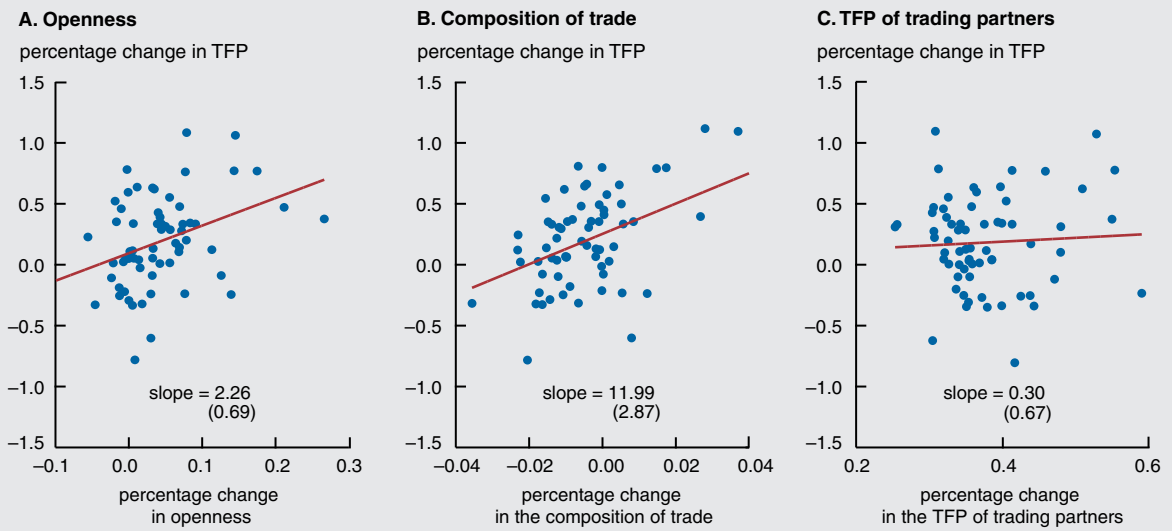
Our model nests, at two extremes, a model of pure innovation[9] and a model of pure diffusion.[10] We have our model span these two extremes by varying a single parameter, β, which we label the strength of diffusion. The parameter β measures the contribution of insights from others to the productivity of new ideas. One striking observation is that for either of these two extremes, if a moderately open country lowers its trade costs, the resulting dynamic gains from trade are fairly small, whereas when β is in an intermediate range, the dynamic gains are larger. When β is small so that insights from others are, for the most part, unimportant, it follows immediately that dynamic gains tend to be small. When β is larger, insights from others are more central. However, in the limiting model, as β approaches the extreme of one, a country accrues almost all of the dynamic gains from trade as long as it is not in autarky. A moderately open country is much better off than it would be in autarky, but further reductions in trade costs have little impact. As a consequence, it is only when β is in an intermediate range that the dynamic gains from trade are sizable and would result from reductions in trade costs in the empirically relevant range.

Quantitative exploration

To explore the ability of the theory to account for the evolution of the world distribution of productivity, we specify a quantitative version of the model that includes nontraded goods and intermediate inputs, as well as equipped labor with capital and education. Specifically, we use this version of the model to study the ability of the theory to account for cross-country differences in total factor productivity (TFP)[11] in 1962 and TFP's subsequent evolution through 2000. We use panel data on trade flows and relative prices to calibrate the evolution of bilateral trade costs, and take the evolution of population, physical capital, and human capital (i.e., equipped labor) from the data. Given the evolution of trade costs and equipped labor, our model predicts the evolution of each country's TFP.

Before discussing the results from the calibrated model, we present suggestive reduced-form evidence of the mechanisms emphasized by the theory, which is reminiscent of the early evidence discussed in research about the importance of knowledge spillovers through trade.[12]

1. Total factor productivity (TFP) and trade factors affecting productivity



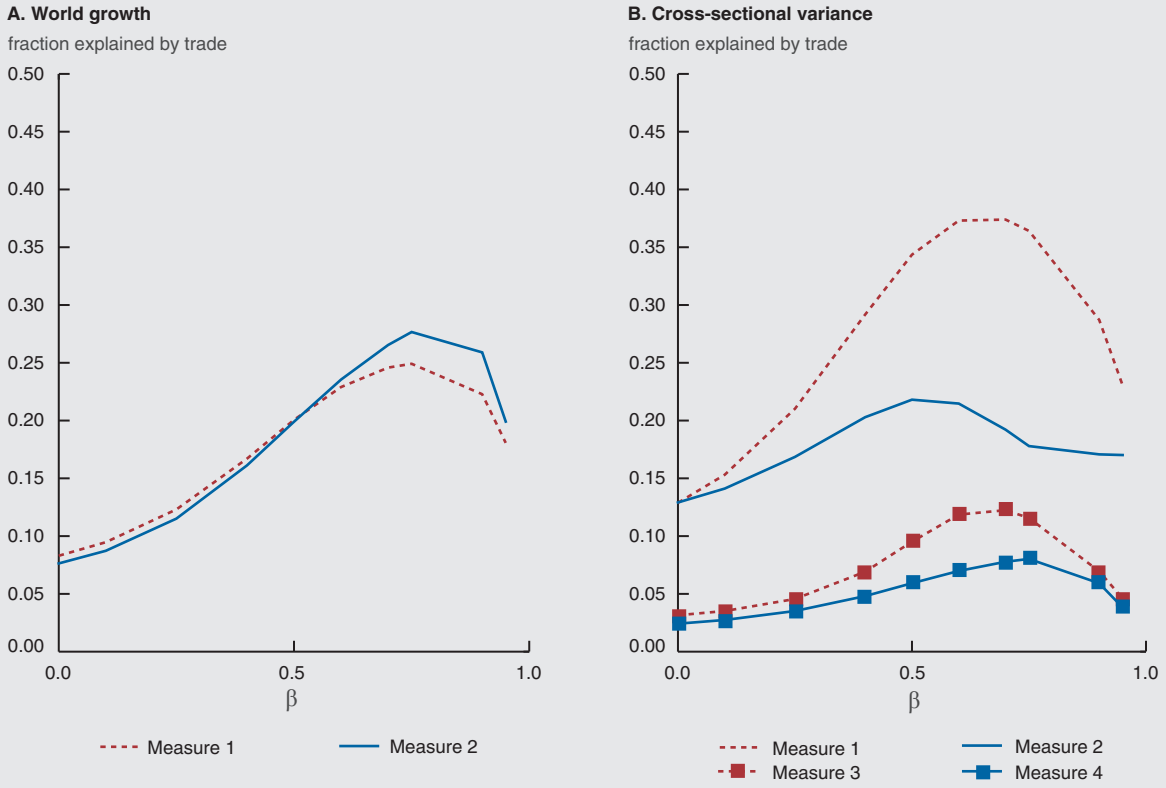
NOTES: See the text for further details on TFP and its relationship with these trade factors. Standard errors of the slopes are in parentheses.
SOURCES: Authors' calculations based on data from the National Bureau of Economic Research–United Nations (NBER–UN) world trade data set, http://cid.econ.ucdavis.edu/wix.html; and Penn World Table (PWT) 8.0, http://www.rug.nl/ggdc/productivity/pwt/earlier-releases.

Over time, among the many factors that would alter a country's productivity, the model emphasizes changes in openness, changing exposure to trading partners, and changes in trading partners' TFP. Figure 1 shows some simple reduced-form patterns in the data. Panel A of figure 1 shows the relationship between changes in openness and changes in TFP. Consistent with the model, countries that increased expenditures on imports tended to have (statistically significantly) larger increases in TFP. Panel B shows the association between the change in countries' composition of trade and TFP growth. Consistent with the theory, there is a clear pattern that countries that increased import exposure to trading partners with high initial productivity saw (statistically significantly) larger increases in TFP. Finally, panel C shows that countries whose trading partners became more productive tended to see increases in TFP. While this relationship is consistent with the model, it is fairly weak and statistically insignificant.

The predicted relationship between trade and TFP depends on the value of β (the strength of diffusion)—which indexes the contribution of insights drawn from others to the productivity of new ideas. While we provide a simple strategy to calibrate this parameter ($\beta = 0.7$), our main approach is to simulate the model for various alternative values and explore how well the model can quantitatively account for cross-country income differences and the evolution of countries' productivity over time.

In figure 2, we present various measures of the extent to which changes in trade costs can account for the distribution of TFP growth rates over the period 1962–2000. Panel A of figure 2 focuses on the role of changes in trade costs in accounting for average TFP growth across the world, while panel B focuses on the fraction of the cross-sectional variance explained by changes in trade costs. In line with our theoretical results, the role of trade in accounting for both the level and dispersion of TFP growth rates is highest for intermediate values of the diffusion parameter, β. The various lines in the figure correspond to alternative ways of constructing counterfactuals (see our working paper for details[13]), but the consistent message is that the contribution of trade is up to three times as large when the model allows for dynamic gains from trade. The quantitative model is quite capable of explaining much of the evolution of TFP in growth miracles, accounting for over one-third of the TFP growth in China, South Korea, and Taiwan.

2. World growth and cross-sectional variance explained by trade



NOTES: The parameter β, which is the strength of diffusion, measures the contribution of insights drawn from others to the productivity of new ideas. See the text and our working paper, Buera and Oberfield (2016), for further details on the different counterfactual measures.

SOURCES: Authors' calculations based on data from the National Bureau of Economic Research–United Nations (NBER–UN) world trade data set, http://cid.econ.ucdavis.edu/wix.html; and Penn World Table (PWT) 8.0, http://www.rug.nl/ggdc/productivity/pwt/earlier-releases.

Conclusion

In our work we provide a tractable theory of the cross-country diffusion of ideas and a quantitative assessment of the role of trade in the transmission of knowledge across nations. Of course, we omitted many channels that may complement or offset the role of trade in the diffusion of ideas. Chief among these is foreign direct investment. Indeed, the structure of our model can be naturally embedded in quantitative models of multinational productions.[14] We see this as an exciting avenue for future research.

[1] A slightly different version of this article recently appeared as a column on VoxEU.org, the policy portal of the London-based Centre for Economic Policy Research, http://voxeu.org/article/global-diffusion-ideas.

[2] See J. Feyrer, 2009, "Trade and income—Exploiting time series in geography," National Bureau of Economic Research, working paper, No. 14910, April, http://www.nber.org/papers/w14910.pdf; J. Feyrer, 2009, "Distance, trade, and income—The 1967 to 1975 closing of the Suez Canal as a natural experiment," National Bureau of Economic Research, working paper, No. 15557, December, http://www.nber.org/papers/w15557.pdf; and L. Pascali, 2014, "The wind of change: Maritime technology, trade and economic development," Warwick Economics Research Papers Series, University of Warwick, Department of Economics, No. 1049, June 25, http://www2.warwick.ac.uk/fac/soc/economics/research/workingpapers/2014/twerp_1049_pascali.pdf.

[3] Earlier work suggested a strong relationship between trade openness and growth; see J. D. Sachs and A. Warner, 1995, "Economic reform and the process of global integration," *Brookings Papers on Economic Activity*, Vol. 26, No. 1, pp. 1–118; D. Dollar, 1992, "Outward-oriented developing economies really do grow more rapidly: Evidence from 95 LDCs, 1976–1985," *Economic Development and Cultural Change*, Vol. 40, No. 3, April, pp. 523–544; D. Ben-David, 1993, "Equalizing exchange: Trade liberalization and income convergence," *Quarterly Journal of Economics*, Vol. 108, No. 3, pp. 653–679; D. T. Coe and E. Helpman, 1995, "International R&D spillovers," *European Economic Review*, Vol. 39, No. 5, May, pp. 859–887; and

J. A. Frankel and D. H. Romer, 1999, "Does trade cause growth?," *American Economic Review*, Vol. 89, No. 3, June, pp. 379–399. However, other research has subsequently argued that many estimates in the literature suffered from econometric issues, including omitted variables, endogeneity, and lack of robustness; see, e.g., F. Rodríguez and D. Rodrik, 2001, "Trade policy and economic growth: A skeptic's guide to the cross-national evidence," in *NBER Macroeconomics Annual 2000*, B. S. Bernanke and K. Rogoff (eds.), Cambridge, MA: MIT Press, pp. 261–338. More recent contributions to the literature (mentioned in note 5) have developed strategies to overcome some of these issues. For a review of the literature, see also R. E. Lucas, Jr., 2009, "Trade and the diffusion of the Industrial Revolution," *American Economic Journal: Macroeconomics*, Vol. 1, No. 1, January, pp. 1–25; R. Wacziarg and K. H. Welch, 2008, "Trade liberalization and growth: New evidence," *World Bank Economic Review*, Vol. 22, No. 2, pp. 187–231; and D. Donaldson, 2015, "The gains from market integration," *Annual Review of Economics*, Vol. 7, No. 1, pp. 619–647.

[4] M. Connolly and K.-M. Yi, 2015, "How much of South Korea's growth miracle can be explained by trade policy?," *American Economic Journal: Macroeconomics*, Vol. 7, No. 4, October, pp. 188–221.

[5] See F. E. Alvarez, F. J. Buera, and R. E. Lucas, Jr., 2013, "Idea flows, economic growth, and trade," National Bureau of Economic Research, working paper, No. 19667, November, http://www.nber.org/papers/w19667.pdf; T. Sampson, 2016, "Dynamic selection: An idea flows theory of entry, trade, and growth," *Quarterly Journal of Economics*, Vol. 131, No. 1, pp. 315–380; J. Perla, C. Tonetti, and M. E. Waugh, 2015, "Equilibrium technology diffusion, trade, and growth," National Bureau of Economic Research, working paper, No. 20881, January, http://www.nber.org/papers/w20881.pdf; and F. J. Buera and E. Oberfield, 2016, "The global diffusion of ideas," Federal Reserve Bank of Chicago, working paper, No. 2016-13, https://www.chicagofed.org/publications/working-papers/2016/wp2016-13.

[6] Buera and Oberfield (2016).

[7] A Fréchet distribution is a type of maximum value distribution (for more details, see http://www.statisticshowto.com/frechet-distribution/).

[8] J. Eaton and S. Kortum, 2002, "Technology, geography, and trade," *Econometrica*, Vol. 70, No. 5, September, pp. 1741–1779; A. B. Bernard, J. Eaton, J. B. Jensen, and S. Kortum, 2003, "Plants and productivity in international trade," *American Economic Review*, Vol. 93, No. 4, September, pp. 1268–1290; and F. E. Alvarez and R. E. Lucas, Jr., 2007, "General equilibrium analysis of the Eaton–Kortum model of international trade," *Journal of Monetary Economics*, Vol. 54, No. 6, September, pp. 1726–1768.

[9] S. Kortum, 1997, "Research, patenting, and technological change," *Econometrica*, Vol. 65, No. 6, November, pp. 1389–1419.

[10] F. E. Alvarez, F. J. Buera, and R. E. Lucas, Jr., 2008, "Models of idea flows," National Bureau of Economic Research, working paper, No. 14135, June, http://www.nber.org/papers/w14135.pdf; and Alvarez, Buera, and Lucas (2013).

[11] TFP refers to the technologies and operational systems that businesses use to combine various inputs into outputs. In other words, TFP captures the residual growth in total output of the national economy that cannot be explained by the accumulation of measured inputs, such as labor and capital.

[12] Coe and Helpman (1995); and D. T. Coe, E. Helpman, and A. W. Hoffmaister, 1997, "North–South R & D spillovers," *Economic Journal*, Vol. 107, No. 440, January, pp. 134–149. For a recent review of this empirical literature, which considers alternative channels (including foreign direct investment), see W. Keller, 2009, "International trade, foreign direct investment, and technology spillovers," National Bureau of Economic Research, working paper, No. 15442, October, http://www.nber.org/papers/w15442.pdf.

[13] Buera and Oberfield (2016).

[14] See, e.g., N. Ramondo and A. Rodríguez-Clare, 2013, "Trade, multinational production, and the gains from openness," *Journal of Political Economy*, Vol. 121, No. 2, April, pp. 273–322.

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