The Empirical Dynamics of Comparative Advantage*

Gordon H. Hanson
UC San Diego and NBER

Nels Lind
UC San Diego

Marc-Andreas Muendler
UC San Diego and NBER

October 4, 2013

Abstract

In this paper, we explore the long run evolution of comparative advantage. We use the gravity model of trade to extract a measure of relative export capability for 135 sectors in 90 countries from 1962 to 2008. These export capabilities can be used to construct a measure of revealed comparative advantage that corrects Balassa's familiar index for the contamination of trade flows by trade costs. We use our estimates of country export capabilities by sector to document two striking empirical regularities in comparative advantage. One is hyper-specialization in exporting: in the typical country exports are highly concentrated in a handful of sectors. Hyper-specialization is consistent with a heavy upper tail in the distribution of export capabilities across sectors within a country, which we find is best approximated by a generalized gamma distribution whose shape is stable across time. The second empirical regularity is a high rate of turnover in a country's top export sectors. High turnover reflects high rates of decay in country export capabilities, which we estimate to be on the order of 35% per decade. To reconcile persistent hyper-specialization in exporting with high rates of decay in export capability, we specify a continuous-time diffusion as a stochastic process for export capability and estimate its parameters in discrete time. The gamma distribution emerges as the stationary distribution for this process. The model we employ, adapted from the study of population dynamics in biology, incorporates congestion effects, which mimic sectoral competition for resources, and innovations in productivity, which capture an evolving process of industrial discovery. The combination of innovations and congestion allows for apparent jumps in export capability—accounting for specialization—and for decay in these capabilities—accounting for turnover. Our results provide an empirical roadmap for dynamic theoretical models of the determinants of comparative advantage.

*Hanson: IR/PS 0519, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0519 (gohanson@ucsd.edu); Lind: Dept. of Economics, University of California, San Diego, 9500 Gilman Drive MC 0508, La Jolla, CA 92093-0508 (nelslind@gmail.com); Muendler: Dept. of Economics, University of California, San Diego, 9500 Gilman Drive MC 0508, La Jolla, CA 92093-0508 (muendler@ucsd.edu).

1 Introduction

Comparative advantage is making a comeback in international trade. After a long hiatus during which the Ricardian model was universally taught to undergraduates but rarely used in quantitative research, the role of comparative advantage in explaining trade flows is again at the center of inquiry. Its return is due in part to the success of the Eaton and Kortum (2002) model (EK hereafter), which gives a probabilistic structure to firm productivity and allows for settings with many countries and many industries.[1] Costinot, Donaldson, and Komunjer (2012) apply an expanded version of EK to data on a dozen sectors in OECD countries for 1997 and find that—as indicative of trade obeying comparative advantage—countries' relative industry productivity is a strong predictor of their relative industry trade flows.[2] After two centuries of lauding Ricardo's insights, economists now have some evidence to validate the attention.

In this paper, we explore the evolution of comparative advantage over the last four and half decades. Our approach, while similar in spirit to Costinot, Donaldson, and Komunjer (2012), does not rely on their method of using product price data to evaluate comparative advantage. Nor do we follow other recent applications of EK that extract information on global industry productivity by combining industry trade flows with industry production data.[3] While these approaches permit tight adherence to the structure of the EK model, they require one to use aggregate industry categories and relatively recent time periods. Instead, we use the gravity model of trade to extract a measure of countries' relative export capability, which we then use to evaluate how comparative advantage changes over time for 135 sectors in 90 countries between 1962 and 2008.

The gravity model, as is now well known, is consistent with a large class of trade models (Anderson, 1979; Anderson and Van Wincoop, 2003; Arkolakis, Costinot and Rodriguez-Clare, 2012). These models have in common an equilibrium relationship in which bilateral trade in a particular sector can be decomposed into three components (Anderson, 2010): an *exporter-sector component*, which captures the exporting country's overall export capability in the sector; an *importer-sector component*, which captures the importing country's effective demand for goods in the sector; and an *exporter-importer component*, which captures bilateral trade costs between the exporting and

[1] Dornbusch, Fischer, and Samuelson (1977), on which EK builds, generalizes Ricardian trade theory to many industries but does not easily extend beyond two countries (Collins, 1985). Shikher (2011, 2012) expands EK to a multi-sector setting.

[2] To be precise, they find a close to one-to-one relationship between two countries' relative bilateral exports of good i (normalized by their relative bilateral exports of some good i') and the two countries' relative productivities in good i (normalized by their relative productivities in i'), where bilateral refers to the exports of each country to a common importer and productivity is measured using industry producer price indexes.

[3] See Chor (2010), Waugh (2010), Finicelli, Pagano, and Sbracia (2009, 2011), Fladinger and Fleiss (2011), and Levchenko and Zhang (2013).

importing countries. In the EK model, the exporter-sector component is the product of a country's overall efficiency in producing goods and of its unit production costs. We interpret this value as a measure of reduced-form absolute advantage in the country's sector.[4] In the Krugman (1979), Melitz (2003), and Anderson and Van Wincoop (2003) trade models, which also yield a gravity specification, the precise functional form of the exporter-sector component differs but its interpretation as representing a country's sectoral export capability still applies.[5] We use data on bilateral trade flows for three-digit SITC sectors from Feenstra et al. (2005) to estimate the exporter-sector component of the gravity model for each year in our sample period. We perform the estimation with and without correcting for zero trade flows.[6]

Our analysis characterizes both the stochastic process that governs the evolution of comparative advantage and the cross-sectional distribution of comparative advantage between countries at a given point in time. While we motivate our approach using EK—where export capability depends on the realized efficiency of a country's industries—we remain agnostic about the origins of comparative advantage. It may be driven by the accumulation of ideas, which Eaton and Kortum (1999) use to microfound the EK model; relative factor supplies as in a Heckscher-Ohlin framework (Trefler, 1995; Davis and Weinstein, 2001; Romalis, 2004; Bombardini et al. 2012); the interaction of industry characteristics and national legal, financial, or labor market institutions (Levchenko, 2007; Costinot, 2009; Cunat and Melitz, 2011); or some combination of these elements. We aim to describe the temporal evolution of countries' export capabilities, which identifies the dynamic properties that any underlying theory of the determinants comparative advantage must satisfy.

After estimating countries' sectoral export capabilities, our analysis proceeds in three stages. First, we show how these export capabilities can be readily assembled to construct an intuitive and familiar measure of comparative advantage. In influential work, Balassa (1965) proposes an ad hoc Revealed Comparative Advantage (RCA) index, defined to be the ratio of a country's share of global exports in a sector to the country's share of global exports across all sectors.[7] Brazil's RCA in soy,

[4]We apply the modifier "reduced form" because the exporter-sector component combines a technological determinant of trade—a country's sectoral efficiency—with an equilibrium consequence of this component—factor prices as embodied in sectoral unit production costs.

[5]The exporter-sector component reflects a home market effect and production costs when gravity is based on a Krugman (1979) model, it captures the mass of potential entrants and production costs when based on a Chaney (2008) version of the Melitz (2003) model, and it captures a demand-side parameter in an Anderson and Van Wincoop (2003) interpretation. In a Heckscher-Ohlin setting, the exporter-sector component reflects the relative size of a country's sector based on factor endowments and sectoral factor intensities (Deardorff, 1998).

[6]See Silva Santos and Tenreyro (2006), Helpman, Melitz, and Rubinstein (2008), Eaton, Kortum, and Sotelo (2012), and Fally (2012) for alternative econometric approaches to account for zero trade between countries.

[7]See Costinot, Donaldson, and Komunjer (2011) for discussion of the relationship between the Balassa RCA index and the EK model. Proudman and Redding (2000) study the time pattern of changes in RCA indexes for G-5 countries.

for instance, will be strong if the country's share of global soy exports is high relative to its share of all global exports. Balassa's RCA index suffers from two conceptual problems. One is that it bears an unknown relationship to the determinants of comparative advantage. A second is that it is contaminated by geography: actual trade flows are affected by trade costs, which obfuscate the relationship between comparative advantage and realized trade. We construct a "geography-free" RCA index, defined to be the ratio of a country's share of global exports in a sector to its share of total global exports that would obtain in a world with uniform trade costs between all markets. While the Balassa RCA index and our geography-free index are highly correlated (with a partial correlation of 0.65), the distribution of our RCA measure is more stable across time, highlighting the manner in which trade costs distort perceptions of changing comparative advantage.

The second stage of our analysis is to document static and dynamic empirical regularities in comparative advantage. We observe two strong and seemingly oppositional tendencies in countries' export capabilities. One is hyper-specialization in exporting.[8] Exports in the typical country are highly concentrated in a small number of sectors. Across the 90 countries in our data, the median share of the top sector (out of 135 total sectors) in a country's total exports is 21%. For the top 3 goods (top 2% of export products) the median export share is 43%, for the top 7 goods (top 5% of export products) it is 64%, and for the top 14 goods (top 10% of export products) it is 80%. These shares are modestly higher for developing countries. Hyper-specialization is consistent with a heavy tailed distribution of export capabilities across sectors within a country. Indeed, applying the approach in Luttmer (2007) we find that the cross-sector distribution of export capability for a country in a given year is consistent with a generalized gamma distribution (Stacy, 1962). The version of the generalized gamma that best fits the data is even heavier in the upper tail than the extreme-value (one-parameter) exponential and (two-parameter) extreme-value distributions, which the (three-parameter) generalized gamma distribution nests as special cases. The approximation with the gamma distribution works well across time, suggesting that there is a considerable degree of stability in the *shape* of the cross-sector distribution of export capabilities. A heavy upper tail indicates that whatever process drives comparative advantage leads countries to be highly capable exporters in only a small number of products in a given year.

Stability in the shape of the distribution of export capabilities makes the second empirical regularity all the more surprising. There is a high rate of turnover in a country's top export products. Among the goods that account for the top 5% of a country's export sectors in a given year, approximately 45% were not in the top 5% 20 years previously. Turnover is consistent with high rates

[8] See Easterly and Reshef (2009), Hanson (2012), and Freund and Pierola (2013) for further discussion.

of decay in country export capabilities. When we regress the long-period change in a country's sectoral export capability on its initial value,[9] we find decadal decay rates in export capability on the order of 35%. As these regressions include sector-time and country-time fixed effects, they are properly viewed as summarizing decay rates in comparative advantage. The mutability of country export capabilities is reminiscent of Bhagwati's (1994) description of comparative advantage as "kaleidoscopic," in which the dominance of a country's top export products can be short lived.

In the third stage of our analysis, we reconcile how persistent hyper-specialization in exports can coexist with high rates of decay in export capability. We specify a continuous-time diffusion as our latent stochastic process for export capability and estimate its parameters in discrete time. The competitive Lotka-Volterra model, or logistic equation, is an empirically successful diffusion for population dynamics (see, e.g., Kuang, 1993), with the gamma distribution arising as the stationary distribution for this process (Leigh, 1968). As we show, a power function of the Lotka-Volterra model yields a stationary distribution that is generalized gamma, which closely fits the distribution of countries' sectoral export capabilities that we estimate. The original competitive Lotka-Volterra model tracks the size of a species and its rate of growth under congestion effects; our conceived economic counterpart is a country's sector confronting limited local resources as its export capability evolves. Congestion combined with diffusion creates the possibility for apparent "jumps" in export capability, though the underlying process itself is smooth. In validation exercises, we document that estimates of the transformed Lotka-Volterra model of individual countries' sectoral export capabilities yield plausible predictions for the cross sectional distributions of relative export capabilities between countries and over time.

A growing literature, to which our work contributes, employs the gravity model of trade to estimate the determinants of comparative advantage.[10] Chor (2010) uses bilateral trade flows for 20 manufacturing sectors in 1990 to explore whether the interaction of industry factor intensity with national institutions and national factor supplies can explain cross-sector variation in export volume. Fadinger and Fleiss (2011) perform a similar exercise across time using country exports relative to the United States for 24 manufacturing sectors from the 1980s to the 2000s.[11] They find that the implied gap in country export capability vis-a-vis the U.S. closes as per capita GDP converges to U.S. levels. Waugh (2010) combines product price data with the gravity model, based on trade flows observed in 1996, to identify asymmetries in trade costs between rich and poor countries, which in

[9] This regression follows empirical work on income mobility for individuals over time (e.g. Fields et al., 1999).

[10] Related work examines changes in patterns of export diversification over time (Imbs and Wacziarg, 2003; Cadot, Carrere, and Strauss-Kahn, 2011).

[11] For related work on using the gravity model to evaluate sectoral productivity, see Waugh (2010) and Finicelli, Pagano, and Sbracia (2009, 2011).

turn contribute to cross-country differences in income. Levchenko and Zhang (2013) calibrate the EK model to data on bilateral trade flows and sectoral production, which yields estimates of EK's overall efficiency levels for 19 manufacturing sectors across time. They find that efficiency levels have converged across countries, weakening comparative advantage in the process.

Our approach differs from the literature in two related and important respects. We impose less structure on the data—using a general gravity model and not functional forms specific to EK or other trade models—and we examine all merchandise sectors (including manufacturing and non-manufacturing) at the finest level of disaggregation possible.[12] What we gain by this approach is a perspective on hyper-specialization in exporting and turnover in top export goods that is less apparent in data that are limited to manufacturing and that use aggregate industry categories. What we lose by this approach is the ability to decompose country export capabilities into their underlying components (as in Chor, 2011) and to evaluate the welfare consequence of changes in comparative advantage (as in Levchenko and Zhang, 2013). These exercises require incorporating data on sectoral production into trade flows, which necessitates considerable industry aggregation. We leverage our insights on the evolution of sectoral export capabilities to produce a robust empirical specification of the dynamic stochastic process governing these capabilities and the resulting cross sectional distribution of comparative advantage at a given moment in time. Our results provide an empirical roadmap for dynamic theoretical models of the determinants of comparative advantage.

Section 2 of the paper presents a simple theoretical motivation for our gravity specification and derives a geography-free measure of Revealed Comparative Advantage. Section 3 presents the data, our estimates of country export capabilities, and the comparison of our RCA index to the traditional Balassa measure. Section 4 documents the two key empirical regularities regarding comparative advantage: (i) hyper specialization in exporting with heavy upper tails in country export capabilities, and (ii) high turnover in countries' top export goods associated with high decay rates in export capabilities. Section 5 presents our estimates of the diffusion process for country export capabilities and shows how the model we estimate can account for apparent jumps in countries' absolute advantage. Section 6 concludes the paper by discussing what our results imply about theoretical approaches to modeling the determinants of comparative advantage.

[12] This level is that which permits consistent sector definitions across the four decades of our data (Feenstra et al., 2005).

References

Anderson, James E. 1979. "A Theoretical Foundation for the Gravity Equation." *American Economic Review,* 69(1): 106–16.

Anderson, James E. 2010. "The Gravity Model." *Annual Review of Economics,* 3: 133–60.

Anderson, James E., and Eric van Wincoop. 2003. "Gravity with Gravitas: A Solution to the Border Puzzle." *American Economic Review,* 93(1): 170–92.

Arkolakis, Costas. 2010. "Market Penetration Costs and the New Consumers Margin in International Trade." *Journal of Political Economy,* 118(6): 1151–99.

Arkolakis, Costas, Arnaud Costinot, and Andres Rodriguez-Clare. 2012. "New Trade Models, Same Old Gains?" *American Economic Review*, 102(1): 94-130.

Balassa, Bela. 1965. "Trade Liberalization and Revealed Comparative Advantage." *The Manchester School of Economic and Social Studies*, 33: 99–123.

Bhagwati, Jagdish. 1994. "Free Trade: Old and New Challenges." *Economic Journal*, 104(423): 231-246.

Bombardini, Matilde, Giovanni Gallipoli, and German Pupato. 2012. "Skill Dispersion and Trade Flows." *American Economic Review*, 102(5): 2327-2348.

Cadot, Olivier, Celine Carrere, and Vanessa Strauss-Kahn. 2011. "What's Behind the Export Hump?" *Review of Economics and Statistics*, 93(2): 590-605.

Chaney, Thomas. 2008. "Distorted Gravity: The Intensive and Extensive Margins of International Trade." *American Economic Review,* 98(4): 1707–21.

Chor, Davin. 2010. "Unpacking Sources of Comparative Advantage: A Quantitative Approach." *Journal of International Economics,* 82(2): 152–67.

Collins, Susan. 1985. "Technical Progress in a Three-Country Ricardian Model with a Continuum of Goods." Journal of International Economics, 19(1-2): 171-179.

Costinot, Arnaud. 2009. "On the Origins of Comparative Advantage." *Journal of International Economics*, 77: 255-264.

Costinot, Arnaud, Dave Donaldson, and Ivana Komunjer. 2012. "What Goods Do Countries Trade? A Quantitative Exploration of Ricardo's Ideas." *Review of Economic Studies*, 79(2): 581-608.

Cunat, Alejandro, and Marc Melitz. 2011. "Volatility, Labor Market Flexibility, and the Pattern of Comparative Advantage." *Journal of the European Economic Association*, 10(2): 225-254.

Davis, Donald, and David Weinstein. 2001. "An Account of Global Factor Trade." *American Economic Review*, 91(5): 1423-1453.

Deardorff, Alan V. 1998. "Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?," in Jeffrey A. Frankel, ed., *The Regionalization of the World Economy*, Chicago: University of Chicago Press, chapter 1: 7–32.

Dornbusch, Rudiger, Stanley Fischer, and Paul Samuelson. 1977. "Comparative Advantage, Trade, and Payments in a Ricardian Model with a Continuum of Goods." *American Economic Review*, 67(5): 823-839.

Easterly, William, and Ariell Reshef. 2009. "Big Hits in Manufacturing Exports." Mimeo, New York University.

Eaton, Jonathan, and Samuel Kortum. 1999. "International Technology Diffusion: Theory and Measurement." *International Economic Review*, 40(3): 537-570.

Eaton, Jonathan, and Samuel Kortum. 2002. "Technology, Geography, and Trade." *Econometrica*, 70(5): 1741-1779.

Eaton, Jonathan, Samuel Kortum, and Francis Kramarz. 2011. "An Anatomy of International Trade: Evidence from French Firms." *Econometrica*, 79(5), 1453-1498.

Eaton, Jonathan, Samuel Kortum, and Sebastian Sotelo. 2012. "International Trade: Linking Micro and Macro." NBER Working Paper No. 17864.

Fadinger, Harald, and Pablo Fleiss. 2011. "Trade and Sectoral Productivity." *Economic Journal*, 121: 958-989.

Fally, Thibault. 2012. "Structural Gravity and Fixed Effects." Mimeo, University of Colorado.

Feenstra, Robert C., Robert E. Lipsey, Haiyan Deng, Alyson C. Ma, and Hengyong Mo. 2005. "World Trade Flows: 1962-2000." NBER Working Paper No. 11040.

Fields, G.S., Ok, E.A. 1999. "The Measurement of Income Mobility." In Silber, J., ed. *Handbook of Income Distribution Measurement*. Boston: Kluwer.

Finicelli, Andrea, Patrizio Pagano, and Massimo Sbracia. 2009. "Trade Revealed TFP." Bank of Italy Working Paper No. 729.

Finicelli, Andrea, Patrizio Pagano, and Massimo Sbracia. 2013. "Ricardian Selection." *Journal of International Economics*, 89: 96-109.

Freund, Caroline, and Martha Denisse Pierola. 2013. "Export Superstars." Mimeo, World Bank.

Hanson, Gordon. 2012. "The Rise of Middle Kingdoms: Emerging Economies in Global Trade." *Journal of Economic Perspectives*, 26(2): 41-64.

Harrigan, James. 1997. 'Technology, Factor Supplies, and International Specialization: Estimating the Neoclassical Model." *American Economic Review*, 87(4): 475–94.

Helpman, Elhanan, Marc J. Melitz, and Yona Rubinstein. 2008. "Estimating Trade Flows: Trading Partners and Trading Volumes." *Quarterly Journal of Economics,* 123(2): 441–87.

Hsieh, Chang-Tai, and Ralph Ossa. 2012. "A Global View of Productivity Growth in China." NBER Working Paper No. 16778.

Imbs, Jean, and Romain Wacziarg. 2003. ''Stages of Diversification." *American Economic Review,* 93(1): 63–86.

Krugman, Paul. 1980. "Scale Economies, Product Differentiation, and the Pattern of Trade." *American Economic Review,* 70(5): 950–9.

Kuang, Yang. 1993. *Delay differential equations: With applications in population dynamics*, Vol. 191 of *Mathematics in science and engineering*, Boston: Academic Press.

Leigh, Egbert G. 1968. "The Ecological Role of Volterra's Equations," in Murray Gerstenhaber, ed., *Some mathematical problems in biology*, Vol. 1 of *Lectures on mathematics in the life sciences*, Providence, Rhode Island: American Mathematical Society: 19-61. Levchenko, Andrei. 2007. "Institutional Quality and International Trade." *Review of Economic Studies*, 74: 791-819.

Levchenko, Andrei. and Zhang, Jing. 2013. "The Evolution of Comparative Advantage: Measurement and Welfare Implications." Mimeo, University of Michigan.

Luttmer, Erzo G. J. 2007. "Selection, Growth, and the Size Distribution of Firms." *Quarterly Journal of Economics*, 122(3): 1103–44.

Melitz, Marc J. 2003. "The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity." *Econometrica,* 71(6): 1695–1725.

Proudman, James, and Stephen Redding. 2000. "Evolving Patterns of International Trade." *Review of International Economics*, 8(3): 373-396.

Romalis, John. 2004. "Factor Proportions, and the Structure of Commodity Trade." *American Economic Review*, 94(1): 67-97.

Shikher, Serge. 2011. "Capital, Technology, and Specialization in the Neoclassical Model." *Journal of International Economics*, 83(2): 229-242.

Shikher, Serge. 2012. "Putting Industries into the Eaton-Kortum model." *Journal of International Trade and Economic Development*, 21(6): 807-837.

Santos Silva, J.M.C., and Silvana Tenreyro. 2006. "The Log of Gravity." *Review of Economics and Statistics*, 88(4): 641-658.

Stacy, E. W. 1962. "A Generalization of the Gamma Distribution," *Annals of Mathematical Statistics*, September 1962, 33(3): 1187-1192.

Trefler, Dan. 1993. "International factor price differences: Leontief was right!" *Journal of Political Economy*, 101(6):961–87.

Trefler, Dan. 1995. "The Case of the Missing Trade and Other Mysteries." *American Economic Review*, 85(5): 1029-1046.

Waugh, Michael. E. 2010. "International Trade and Income Differences." *American Economic Review*, 100: 2093-2124.