The Korean Economic Review
Volume 27, Number 1, Summer 2011, 115-138.

Accounting for Learning-by-Doing in Foreign Trade

Namsuk Choi*

This paper attempts to account comprehensively for the role of learning-by-doing (LBD) in foreign trade. The importance of LBD on export performance is accounted for at various levels of aggregation, such as LBD at the product level, LBD at the market level, and more specifically, LBD at the market-and-product level. Using panel data covering 130 countries and 1,003 products during the period between 1962 and 2000, this paper finds a positive but concave relationship between foreign trade and LBD at various export levels, even after controlling for country income effects, openness, and per-capita GDP growth rates. Such relationship is stronger and less bounded at the product-specific level. However, with more meaningful changes, LBD at the market-specific level becomes more important than that at the product-specific level over a longer period of time.

JEL Classification: F10, I20, J24, O11, O31, O40
Keywords: Learning-by-Doing, Human Capital, Export Margin, Trade

I. Introduction

Why do some economies export more than others?[1] One view holds that the extent of learning-by-doing (LBD) is crucial in understanding the dynamics of aggregate exports.[2] Although many recent works on the role of LBD in foreign trade

Received: Oct. 5, 2010. Revised: Jan. 3, 2011. Accepted: March 22, 2011.

* Korea Economic Research Institute, 8th Fl., Hana Daetoo Securities Bldg., 27-3, Yeouido-dong, Yeongdeungpo-gu, Seoul, 150-705, KOREA. E-mail: nchoi@keri.org. Phone: 82-2-3771-0037. Fax: 82-2-785-0272. All errors are mine alone. I am grateful to Murat Iyigun for his guidance and encouragement. I also thank Wolfgang Keller, Keith Maskus, Robert McNown, David Brown, and two anonymous referees for their valuable comments and suggestions.

[1] Hummels and Klenow (2005) show that large economies export more and that the extensive export margin (a wider variety of goods) explains the greater quantity of exports in the larger economies. Hausmann, Hwang, and Rodrik (2007) report the reasons why countries produce and export specific products and such activities matter.

[2] An and Iyigun (2004b) find that learning by exporting, through which an economy accumulates the skill content of exports, influences foreign trade specialization and affects economic growth. Yoon (2005) incorporates the dynamic feedback effects of Southern imitation and Northern innovation into

exist, there is little evidence on specific mechanisms through which LBD in foreign trade increases export performance.[3] The current paper focuses on this topic by accounting for the importance of learning at various levels of aggregation, such as LBD at the *market* level, LBD at the *product* level, and more specifically, LBD at the *market-and-product* level.

Empirical studies based on disaggregate data have found that the extensive and intensive margins serve as channels of export growth.[4] Despite the extensive application of LBD, it is not clear how it can help explain the variations of the intensive and extensive export margins across time. The relationship of LBD to foreign trade patterns is explored through the intensive and extensive export margins. In doing so, this paper investigates comprehensively whether or not LBD grows more rapidly and increases export performance significantly at the broader export levels over a longer time horizon. We aim to answer the following question: Do countries with higher (lower) initial levels of cumulative export experience at the broader export market level tend to export more (less) to trade partners?

Using panel data covering 130 countries and 1,003 products during the period between 1962 and 2000, dynamic and nonlinear panel regressions are performed, and the effects of cumulative per-capita export experience on export performance are estimated. A positive and significant but concave relationship is found between foreign trade and LBD at various levels of aggregation, even after controlling for country income effects, openness, and economic growth. Such relationship is stronger and less bounded at the *product-specific* level. In particular, the narrowing of LBD to the world frontier level of LBD by 1-standard deviation at the *market-and-product-specific*, *product-specific*, and *market-specific* levels increases exports per-capita by 7.7%, 26.6% and 23.4%, respectively.

For the purpose of this paper, LBD in foreign trade is defined as the process of acquiring knowledge and skills through cumulative export experience. This paper is primarily interested in export experience at various export levels. The learning experience may be accumulated at the *product-specific* and/or *market-specific* levels. In this case, both levels may be channels through which knowledge and skills are easily acquired.

This paper empirically examines why *product-specific* LBD might be most important and why *market-specific* LBD gets stronger over a longer period of time. Theoretically, the choice of technology leads to improvements within products

LBD in the North-South trade and shows the long-run effects of trade-induced LBD on economic growth.

[3] See, for instance, An and Iyigun (2004a), Bernard and Jensen (1999), Chuang (1998), Van Biesebroeck (2005), and Young (1991).

[4] For instance, Hummels and Klenow (2005) use 1995 United Nations data that cover exports over 5,000 to 13,000 product categories; the extensive export margin explains 62% of the increased exports of bigger economies.

because technology and human capital are embodied in a product (Jovanovic and Nyarko 1996). Moreover, the learning potential on *product-specific* technology may dilute large fixed costs of exporting (Melitz 2005). Thus, a quantification of LBD at the *product-specific* level may shed light on channels of transfer of technology, through which LBD increases export performance (Keller 2009).

Exporting to a specific market may help economies accumulate learning on the *market-specific* assets. Institutions, infrastructure, property rights, or regulations are relatively *market-specific* non-tradable assets. However, the degree of factor substitutability for those institutional assets is discrete and is heterogeneous at the network of relatedness across products (Hidalgo et al. 2007). Thus, learning on *market-specific* assets may help countries transform their productive structure and upgrade their export mix across products at the same time.

The evidence from this study supports the idea that countries with higher levels of initial LBD at the *product-specific* level than at the narrower *market-and-product-specific* level tend to export more. On the other hand, countries with lower levels of initial LBD at the *product-specific* level than at the narrower *market-and-product-specific* level tend to export less. Thus, foreign trade-induced LBD at the *product-specific* level seems to be more important than that at the *market-and-product-specific* level. Furthermore, learning at the *market-specific* level with more meaningful changes over a longer time horizon may be much more important than at the *product-specific* level.

II. Literature Review

There exist two strands of literature in Economics that help explain LBD in foreign trade. First, there are papers that discuss LBD and the patterns of foreign trade flows. LBD affects the revealed comparative advantage of various nations. When agents maximize a *product-specific* technology, learning is accumulated, and their productivity is improved (Jovanovic and Nyarko 1996). This increased productivity improves products. However, this form of human capital is *product-specific*, and gains in the given product are limited. Agents can move on to new products to surpass the limit. The relation of the new products to the old ones determines the potential for moving on to new products. Hidalgo et al. (2007) build a model of the product space by generalizing the degree of substitutability across products. The model then explains improvements between products.

Industry protection policies depend on learning associated with exporting. Analyzing an industry's learning potential and the shape of the learning curve helps in selecting an infant-industry protection policy (Melitz 2005). The production costs of an industry associated with learning process drop over time, and learning is exhausted once the industry reaches the constant costs level. Export subsidies have similar characteristics to infant industry policies. Export subsidies are attractive policy tools in an industry affected with larger spillovers (Brander and Spencer 1985). In the commercial aircraft industry, Pavcnik (2002) examines the trade disputes of the Airbus-Boeing rivalry to analyze the effects of export subsidy. However, these studies have not incorporated LBD in the high-tech industry. Using a dynamic estimation model of firm cost function with LBD, Ohashi (2005) shows that export subsidies can increase the positive effects of LBD on the steel-production process in the Japanese steel industry. The intra-industry spillover effect of the export subsidy on industry growth is negligible because the industry supply function is inelastic to the changes of the export subsidy level.

Empirical papers explore LBD and related technology content to explain the patterns of foreign trade. An and Iyigun (2004a) show that LBD in export is positively related—at a statistically significant level—to the technology content of foreign trade. Furthermore, they show that LBD in production has little identification with the technology content of foreign trade. They further explore the interplay between trade-induced LBD and export technology content: economies with higher levels of cumulative per-capita export experience tend to export high technology-content goods, while economies with lower levels of cumulative per-capita export experience produce and export standardized low-technology goods. These findings do not illuminate the specific type of LBD, which is important in identifying LBD's role in exports and foreign trade. The link between export history and the patterns of foreign trade is investigated by comprehensively identifying the effects of LBD at various export levels on export performance.

The second strand of literature explores how economic growth in open economies depends on LBD. In free trade, the less-developed country (LDC) exhausts LBD and always has lower levels of technological progress and growth rates compared with those under autarky. The developed country (DC) experiences faster technological progress and more rapid growth rates at the expense of the LDC, which has already exhausted learning (Young 1991).[5] However, the DC-LDC trade endogenously generates a technology gap between Southern imitation and Northern innovation in the long run, and the dynamic feedback effects of LBD in the DC-LDC trade yield the same higher steady-state long-run growth rate at which both the LDC and the DC grow (Yoon 2005). Nonetheless, the LDC may overtake the DC through LBD in exports. The bridge between LBD and economic growth might be export performance. In this case, learning-by-exporting is an

[5] Young (1991) shows that there exists a division between the developed country (DC) and the less developed country (LDC). At a given development level of new goods and the production process, LBD exploits productive potentials. Nevertheless, free trade may increase the welfare gains of LDC consumers, and LBD has an impetus that explains the movement along the international ladder of production in both countries.

important factor, which determines export performance augmented through the export margins (Hummels and Klenow 2005). Furthermore, the specific products an economy chooses to export influence its economic growth (Hausmann et al. 2007).

Export performance is augmented through extensive and intensive export margins. The intensive margin can be observed in countries that export larger quantities of each goods to already established trading partners. The margin can be increased more intensively by survival or by deepening the relationships through old pathways at the *market-and-product-specific* level (Besedes and Prusa 2007). On the other hand, the extensive margin rises at the *product-specific* level or at the broader *market-specific* level. Exporters open more channels to export a specific product to new trading partners or a wider set of goods to a specific market. The export of the specific product rises by extending to new trading partners in other countries; in addition, exports to the specific market increase in volume by exporting more varieties. Hummels and Klenow (2005) demonstrate why large countries export more quantities than do small countries. They provide evidence that large countries export through the extensive margin, and such exports account for 60% of the greater exports of the bigger economies. Within a specific product category, richer countries export higher quantities with relatively higher prices. Hummels and Klenow (2005) also explain the tendency of larger countries to export a wider set of goods to a specific country by using models with fixed exporting costs to a specific market. The present paper explains the importance of LBD in accounting for the intensive margin at the *market-and-product-specific* level as well as the extensive margins at the *product-specific* and *market-specific* levels.

The product an economy exports matters for its economic growth; this is because countries that export higher productivity goods become richer, while poor countries remain poor by exporting other goods that are typically exported by other poor countries (Hausmann et al. 2007). The export mix chosen by an economy is determined partly by the number of entrepreneurs that can be engaged in LBD with regards the underlying cost structure of the economy. Hausmann et al. (2007) focus on the spillovers in cost-reduction information using the entrepreneur's cost discovery as a way to internalize knowledge externalities. Their study differentiates the *product-specific* LBD from other LBDs in greatly increasing exports and reducing the fixed costs of exporting rich-country goods.

Some empirical studies have explored the channels through which LBD is utilized to induce economic growth at the broader *market-specific* level or at the *product-specific* level. Feenstra and Rose (2000) order countries according to how soon they export high technology commodities to the U.S. market. They show that countries that export sooner to a specific market grow faster than those that export later. An and Iyigun (2004b) investigate whether or not the export skill contents are statistically significant in explaining persistent economic growth, even after controlling for GDP per-capita, investment share, human capital stock, openness, political stability, and terms of trade. They find that the skill content of exports influences the learning process and affects economic growth. Other empirical studies based upon firm level heterogeneity also support the idea that LBD affects export performance. The link between LBD and export growth is the transfer of technology through the exporting experience between firms across countries (e.g., Bernard and Jensen 1999; Van Diesebroeck 2005; De Loecker 2007). Keller (2009), meanwhile, explains how exporting can be a channel for international technology transfer.

The remainder of the current paper is organized as follows. Section 3 discusses the empirical issues, methodology, and data. Section 4 presents the results and an analysis of robustness. Section 5 presents conclusions.

III. The Empirical Analysis

We hypothesize that countries with higher (lower) initial levels of cumulative export experience at the *product-specific* level tend to export more (less).

Learning at the *product-specific* level is highly important in increasing export performance, partly because technology and human capital are embodied in a product. On the one hand, LBD in export at the *product-specific* level is related to theoretical contributions: first, the choice of technology leads to improvements within products (Jovanovic and Nyarko 1996); second, learning potential on industry-specific technology may dilute large fixed costs of exporting (Melitz 2005). On the other hand, LBD in export at the *product-specific* level enhances the effects of three empirical findings on exports and foreign trade: first, LBD in export affects the technology content of foreign trade (An and Iyigun 2004a); second, the export of a specific product rises by extending to new trading partners in other countries (Hummels and Klenow 2005); and third, the link between LBD and export growth is the transfer of technology through the exporting experience between firms across countries (e.g., Bernard and Jensen 1999; Van Diesebroeck 2005; De Loecker 2007).

Learning at the *market-specific* level becomes highly important if the degree of substitutability of *market-specific* assets is discrete and heterogeneous at the product space (Hidalgo et al. 2007). Institutions, infrastructure, property rights, regulations, or any public goods are relatively *market-specific* non-tradable assets, and the *market-specific* characteristics generate the relatedness of products. Exporting to a specific market helps economies accumulate learning on the *market-specific* assets, thus transforming their productive structure and upgrading their export mix across products. In addition, learning at the *market-specific* level increases export performance because it helps an economy export more varieties of high-quality goods to a specific market (Hummels and Klenow 2005).

Learning at the *market-and-product-specific* level becomes highly important if exporting a specific product to a specific market is an efficient way to learn *product-specific* technology and *market-specific* institutional assets. Learning at the *market-and-product-specific* level helps an economy export larger quantities of each goods to already established trading partners, increasing export performance (Besedes and Prusa 2007).

Based upon the empirical literature, a potential linkage between LBD and export performance is expected. On the one hand, the empirical evidence supports the link between LBD and the extensive export margin.[6] On the other hand, there exists support for the idea that LBD is bounded from above.[7] Taking these features together, it is possible that LBD in exports is bounded from above. However, the upper-bounds and the speed of LBD change as the exports are extended from the *market-and-product-specific* level to the *product-specific* level to the extent that returns to scale exist (one way or another). LBD at the narrow or broader levels of definition can have different effects. In this paper, we examine whether or not such considerations render LBD at various levels of aggregation more important for exports and foreign trade.

The measures of LBD are similar to those used by An and Iyigun (2004a). Relevant proxies of LBD should be appropriate to control strong growth trends in exports as well as the bilateral relationship between an exporting country and its trading partners. Thus, the proxies of relative LBD variables can be the per-capita cumulative exports relative to the highest per-capita cumulative exports at the global level. These proxies are chosen to understand how exports per-capita in a country is influenced by foreign trade-induced LBD at various levels of aggregation.

The LBD variables are built by summing up the respective exports per-capita amount, $Export\ performance_{ijk\tau}$, from the initial year to the current year at the narrower *market-and-product-specific* level, at the *product-specific* level, and at the broader *market-specific* level.[8] To normalize the variables, each LBD variable is divided by the highest value of LBD at a corresponding export level in a given year. Three LBD variables are built as described below.

(1) *Market-and-product-specific* LBD_{ijkt} in Equation (1) is country *i*'s trade-induced LBD in the export of product *k* to country *j* at time *t* at the narrower *market-and-product-specific* level.[9]

---

[6] See Hummels and Klenow (2005) and De Loecker (2007).

[7] See Young (1993), Jovanovic and Nyarko (1996), and Yoon (2005).

[8] $Export\ performance_{ijkt} = EXP_{ijkt}/N_{it}$ where EXP_{ijkt} is the PPP adjusted exports of a product *k* from an export country *i* to an import country *j* at time *t*. Here, N_{it} denotes the population of country *i* at time *t*.

[9] For instance, if *j* is the USA and *k* is a semiconductor product, then *market-and-product-specific* LBD_{ijkt} shows country *i*'s cumulative per-capita export experience of semiconductors to the USA in year *t* relative to the highest per-capita export experience of the country that exports semiconductors to

$$\textit{Market-and-product-specific } LBD_{ijkt} = \frac{\sum_{\tau=1}^{t} \textit{Export performance}_{ijk\tau}}{\max_i \sum_{\tau=1}^{t} \textit{Export performance}_{ijk\tau}} \tag{1}$$

(2) *Product-specific* LBD_{ikt} in Equation (2) is country i's trade-induced LBD in the export of product k to the entire world at time t at the *product-specific* level.[10]

$$\textit{Product-specific } LBD_{ikt} = \frac{\sum_{\tau=1}^{t} \sum_{j=1}^{J} \textit{Export performance}_{ijk\tau}}{\max_i \sum_{\tau=1}^{t} \sum_{j=1}^{J} \textit{Export performance}_{ijk\tau}} \tag{2}$$

(3) *Market-specific* LBD_{ijt} in Equation (3) is country i's trade-induced LBD in the exports of all products to country j at time t at the broader *market-specific* level.[11]

$$\textit{Market-specific } LBD_{ijt} = \frac{\sum_{\tau=1}^{t} \sum_{k=1}^{K} \textit{Export performance}_{ijk\tau}}{\max_i \sum_{\tau=1}^{t} \sum_{k=1}^{K} \textit{Export performance}_{ijk\tau}} \tag{3}$$

3.1. Empirical Issues and Methodology

Fixed effects exist within a country's export distribution over the time horizon. These effects are controlled by different dummy variables for export country, import country, year, and product type. However, there is a tradeoff between efficiency of fixed effects and more meaningful changes in export experience. Using additional time periods between observations allows more meaningful changes in the LBD in foreign trade. However, reducing time series observations decreases the efficiency of controlling fixed effects. Thus, we consider alternative LBD variables built upon the various time periods ranging from observations of 1-year, 5-year average, and 10-year average exports. Such consideration for alternative variables helps in understanding how meaningful changes in the export experience account for export performance, even after controlling for all time, country, and *product-specific* characteristics.

Reverse causality may exist because each LBD variable is the stock variable built

---

the USA in the year t. This LBD variable is the narrowest of the three that we shall focus on below.

[10] For instance, if k refers to semiconductors, then *product-specific* LBD_{ikt} shows country i's cumulative per-capita export experience of semiconductors to the entire world in year t, which is relative to the highest cumulative per-capita export experience of the country that exports semiconductors to the entire world in the year t.

[11] For instance, if j is the USA, then *market-specific* LBD_{ijt} shows country i's cumulative export experience of all products to the USA in year t, which is relative to the highest cumulative export experience of all products in the country that exports to the USA in the year t.

upon the history of the exports flow variable. To control this problem, four restrictions are applied. First, each of the explanatory variables is applied with a time lag, thus controlling the contemporaneous effect between explanatory variables and the dependent variable. Second, the lagged dependent variables are controlled as covariates. Autocorrelation problems are contained by controlling two-period lagged dependent variables. Third, initial export experiences are constructed and a 5-year gap to the following export performance is allowed. Fourth, a two-decade export history is used to build the initial LBD variable. This is done in order to control for endogeneity.

The effects of the cumulative learning experience of exporting at various levels of aggregation on the export performance are estimated using the following:

$$\begin{aligned}
&\textit{export performance}_{ijkt} \\
&\quad = \beta_0 + \beta_1 \textit{export performance}_{ijkt\text{-}1} + \beta_2 \textit{export performance}_{ijkt\text{-}2} \\
&\quad + \beta_3 \textit{market-and-product-specific LBD}_{ijkt\text{-}1} \\
&\quad + \beta_4 \textit{market-and-product-specific LBD}^2_{ijkt\text{-}1} + \beta_5 \textit{product-specific LBD}_{ikt\text{-}1} \\
&\quad + \beta_6 \textit{product-specific LBD}^2_{ikt\text{-}1} + \beta_7 \textit{market-specific LBD}_{ijt\text{-}1} \\
&\quad + \beta_8 \textit{market-specific LBD}^2_{ijt\text{-}1} + \boldsymbol{Z}_{it}\boldsymbol{\beta} + \textit{export country fixed effects}_i \\
&\quad + \textit{import country fixed effects}_j + \textit{product fixed effects}_k \\
&\quad + \textit{time fixed effects}_t + \varepsilon_{ijkt} \qquad (4)
\end{aligned}$$

where *export performance*$_{ijkt}$ is the PPP-adjusted exports per-capita of product k from a country i to a country j at time t, and *export performance*$_{ijkt\text{-}1}$ and *export performance*$_{ijkt\text{-}2}$ are its lagged variables for one period and two periods behind, respectively. *Market-and-product-specific LBD*$_{ijkt\text{-}1}$, *product-specific LBD*$_{ikt\text{-}1}$, and *market-specific LBD*$_{ijt\text{-}1}$ are the measures of the relative cumulative per-capita export experience at the *market-and-product-specific*, *product-specific*, and broader export *market-specific* levels, respectively, in the preceding years. The quadratic terms of those measures are used to account for the bounded LBD at various export levels.

In Equation (4), $\boldsymbol{Z}_{it}$ is a vector of additional control variables that may explain export performance. The vector of control variables $\boldsymbol{Z}_{it}$ includes the following: *GDP per capita*$_{it}$ is the PPP-adjusted real GDP per-capita of a country i at time t, and a higher level of GDP per-capita associated with diminishing marginal exports is expected. *Openness*$_{it}$ is a measure of trade volume as a percentage of GDP to proxy the openness of a country i at time t, and an increase in exports is conjectured. *GDP growth*$_{it}$ is the growth rate of PPP-adjusted real GDP per-capita of a country i at time t, and the increase in the rate of economic growth will increase the export performance. *Export country fixed effects*$_i$, *import country fixed effects*$_j$, *product fixed effects*$_k$, and *time fixed effects*$_t$ are controlled in all estimations. We assume that ε_{ijkt} is distributed with a mean of zero and a variance of σ^2_{ijkt} and that the errors contain heteroskedasticity. The variables are listed and defined in [Table 1].

[Table 1] Variable Definitions and Summary Statistics for Panel Data

Variable	Description	Mean	Standard deviation	Min	Max
Export performance (EXPPC)	PPP adjusted per-capita exports k of a country i to a country j at t.	0.0076	0.2107	0	81.80
Export performance$_{ijkt-1}$	One-period lagged e*xport performance*.	0.0063	0.1987	0	81.80
Export performance$_{ijkt-2}$	Two-period lagged e*xport performance*.	0.0049	0.1825	0	81.80
Market-and-product-specific LBD (LMP)	Cumulative relative PPP adjusted exports k of a country i to a country j at t.	0.2945	0.3698	$6.72e^{-08}$	1
Market-and-product-specific LBD^2	Squared value of *market-and-product-specific LBD*.	0.2235	0.3755	$4.52e^{-15}$	1
Market-and-product-specific export participation (DMP)	Cumulative export participation count value of a country i that exports product k to a country j in year t.	15.52	7.93	1	34
Market-and-product-specific export participation^2	Squared value of *market-and-product-specific export participation*.	303.88	293.90	1	1156
Product-specific LBD (LP)	Cumulative relative PPP adjusted exports k of a country i to the world at t.	0.2106	0.2817	$3.24e^{-07}$	1
Product-specific LBD^2	Squared value of *product-specific LBD*.	0.1237	0.2664	$1.05e^{-13}$	1
Product-specific export participation (DP)	Cumulative export participation count value of a country i that exports product k to the world at t.	747.41	632.95	2	3489
Product-specific export participation^2	Squared value of *product-specific export participation*.	959256	$1.47e^{6}$	4	$1.22e^{7}$
Market-specific LBD (LM)	Cumulative relative PPP adjusted exports of a country i to a country j at t.	0.1887	0.2609	$8.20e^{-07}$	1
Market-specific LBD^2	Squared value of *market-specific LBD*.	0.1037	0.2438	$6.73e^{-13}$	1
Market-specific export participation (DM)	Cumulative export participation count value of a country i that exports all products to a country j at t.	5733.27	4214.69	3	20346
Market-specific export participation^2	Squared value of *market-specific export participation*.	$5.06e^{7}$	$6.74e^{7}$	9	$4.14e^{8}$
GDP per capita	PPP adjusted GDP per-capita in a country i at t.	15746.52	8412.97	331.11	34364.50
Openness	Total value of exports and imports divided by GDP times 100 in a country i at t.	67.46	60.97	12.15	377.68
GDP growth	Growth rate of PPP adjusted GDP per-capita of a country i at t.	0.059	0.028	–0.120	0.298

Notes: The number of observations for each variable is 853,219.

3.2. Data Sources, Descriptions, and Classifications

To compare changes in export performance, Equation (4) is initially estimated with 5-year sub-periods. In addition, 10-year and 1-year sub-periods are examined. In this work, using 5-year and 10-year averages allow us to include all the observations and comprehensively account for the effects of LBD on export performance. However, annual observations are huge. Thus, a random sampling is done for the yearly data at a given product level, and as many time periods are included as there are within specific panels.

The exports panel data cover the period between 1962 to 2000, and are divided into nine sub-periods: 1962–1964, 1965–1969, 1970–1974, 1975–1979, 1980–1984, 1985–1989, 1990–1994, 1995–1999, and 2000. To alleviate concerns of endogeneity of the LBD variable, at least 20 years of LBD experience are used. The initial LBD variables are built by accumulating exports from 1962 to 1980 and then updating to the subsequent sub-periods. A 5-year gap is created between the dependent variable and the explanatory LBD variables.

The full sample includes 16.6 million observations of non-missing export data on 1,003 products from 130 export countries to 130 import countries between 1962 and 2000. In the panel with 5-year sub-periods, the sample includes approximately 800,000 observations, 130 countries, and 890 products that remained the same from 1962 to 2000. This includes 20 industrialized countries and 110 developing countries.[12]

The data from several sources are compiled, and exports and LBD variables are constructed from NBER-United Nations trade data by Feenstra et al. (2005). The most recent NBER-UN data cover a set of bilateral trade data by commodity for 1962–2000 and are organized by the 4-digit Standard International Trade Classification. The unit of exports is $1,000. The dependent variable, namely, real exports per-capita, is built by dividing the nominal exports by price level and population. Price level, population, and control variables, such as PPP-adjusted real GDP per-capita, PPP-adjusted GDP per-capita growth rate and openness, are obtained from the Penn World Tables (PWT) 6.2. (Summers et al. 2006). The benchmark year in PWT is 1996, and these variables are expressed in 1996 real U.S. dollars. Exports plus imports divided by GDP is used for the openness. [Table 2] presents the correlation between variables.

---

[12] The industrialized countries include Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, United Kingdom, and United States.

[Table 2] The Correlation Matrix

	EXPPC	*LMP*	*LMP^2*	*DMP*	*DMP^2*	*LP*	*LP^2*	*DP*	*DP^2*	*LM*	*LM^2*	*DM*	*DM^2*	*GPC*	*OPEN*	*GR*
Export performance	1	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Market-and-product-specific LBD	0.033	1	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Market-and-product-specific LBD^2	0.032	0.976	1	…	…	…	…	…	…	…	…	…	…	…	…	…
Market-and-product-specific export participation	0.004	0.108	0.085	1	…	…	…	…	…	…	…	…	…	…	…	…
Market-and-product-specific export $participation^2$	0.004	0.096	0.076	0.973	1	…	…	…	…	…	…	…	…	…	…	…
Product-specific LBD	0.039	0.417	0.380	0.071	0.060	1	…	…	…	…	…	…	…	…	…	…
Product-specific LBD^2	0.041	0.378	0.357	0.044	0.036	0.956	1	…	…	…	…	…	…	…	…	…
Product-specific export participation	–0.020	0.080	0.056	0.600	0.587	0.199	0.126	1	…	…	…	…	…	…	…	…
Product-specific export $participation^2$	–0.014	0.077	0.057	0.567	0.580	0.151	0.088	0.943	1	…	…	…	…	…	…	…
Market-specific LBD	0.024	0.429	0.405	0.076	0.075	0.098	0.083	–0.039	–0.019	1	…	…	…	…	…	…
Market-specific LBD^2	0.023	0.376	0.365	0.057	0.057	0.062	0.055	–0.065	–0.041	0.954	1	…	…	…	…	…
Market-specific export participation	–0.009	0.058	0.042	0.457	0.476	–0.072	–0.094	0.282	0.281	0.228	0.189	1	…	…	…	…
Market-specific export $participation^2$	–0.002	0.058	0.044	0.409	0.447	–0.067	–0.082	0.230	0.241	0.213	0.184	0.950	1	…	…	…
GDP per capita	–0.002	0.121	0.095	0.327	0.350	0.163	0.103	0.402	0.369	0.175	0.118	0.617	0.559	1	…	…
Openness	0.036	0.199	0.184	–0.021	–0.009	0.302	0.289	–0.136	–0.111	0.287	0.255	–0.077	–0.066	0.150	1	…
GDP growth	0.012	–0.036	–0.025	–0.163	–0.166	0.031	0.047	–0.132	–0.151	0.004	0.020	–0.196	–0.164	–0.232	0.216	1

Note: The number of observations for each variable is 853,219.

IV. Results

4.1. Initial Estimates

Equation (4) is first estimated using the cumulative relative export per-capita variables at various levels of aggregation as proxies for LBD. The results are shown in [Table 3].

The first two columns show the estimations after controlling for a one-period lagged dependent variable, and columns (3) and (4) show results generated with two-period lagged dependent variables. All the results from columns (1) to (4) reveal that the exports of a country are positively influenced at a statistically significant level by trade-induced LBD at the *product-specific* level. Moreover, LBD at the narrower *market-and-product-specific* level positively affects at a statistically significant level the export performance, although it becomes insignificant when quadratic forms of LBD are added in columns (2) and (4). At the broader *market-specific* level, LBD is positively and statistically significant, but it becomes insignificant when quadratic forms are dropped in columns (1) and (3). Meanwhile, bounded LBD exist at all levels of aggregation, and it is statistically significant at the *product-specific* level and at the broader *market-specific* level.

Other control variables are added in columns (5) to (8). As shown in [Table 3], the effects of LBD at various levels of aggregation on export performance are robust to the inclusion of various econometric specifications and other economic variables related to country income effects, foreign trade volumes, and economic growth. Openness and growth rate of GDP per-capita are positively related at a statistically significant level to export performance in all specifications. Furthermore, GDP per-capita has negative but statistically insignificant effects on export performance. All the results are consistent and robust in these specifications.

Using the estimates in column (8) of [Table 3], we find that the narrowing of LBD to the world frontier level of LBD by 1 standard deviation at the *market-and-product-specific*, *product-specific*, and *market-specific* levels increases exports per-capita by 0.4 (7.7%), 1.3 (26.6%) and 1.1 (23.4%), standard deviations, respectively.[13]

---

[13] *LMP*:

$(\partial EXPPC/\partial LMP|_{LMP=.2945}) = \beta_3 - 2\beta_4 \cdot LMP = .003 - 2\times.0019\times.2945 = 2.08\times10^{-3}$

$(\partial EXPPC/\partial LMP|_{LMP=.2945}) \cdot (\textit{one standard deviation of LMP}) = 2.08\times10^{-3}\times 36.98$

$= 7.7\times10^{-2}$

$7.6952\times10^{-2}/(\textit{one standard deviation of EXPPC}) = 7.7\times10^{-2}/.21 = 0.4$

LP:

$(\partial EXPPC/\partial LP|_{LP=.2106}) = \beta_5 - 2\beta_6 \cdot LP = .0127 - 2\times.0077\times.21 = 9.46\times10^{-3}$

$(\partial EXPPC/\partial LP|_{LP=.2106}) \cdot (\textit{one standard deviation of LP}) = 9.46\times10^{-3}\times 28.17 = 0.266$

$0.26640/(\textit{one standard deviation of EXPPC}) = 0.266/.21 = 1.3$

LM:

$(\partial EXPPC/\partial LM|_{LM=.1887}) = \beta_7 - 2\beta_8 \cdot LM = .0134 - 2\times.0117\times.1887 = 8.98\times10^{-3}$

[Table 3] Panel Data OLS Estimates

	Export performance$_{ijkt}$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Export performance$_{ijkt-1}$	0.9244***	0.9244***	1.175***	1.175***	0.9244***	0.9244***	1.175***	1.175***
	(0.0624)	(0.0624)	(0.1153)	(0.1154)	(0.0624)	(0.0624)	(0.1153)	(0.1153)
Export performance$_{ijkt-2}$	…	…	–0.3194***	–0.3194***	…	…	–0.3193***	–0.3193***
	…	…	(0.0751)	(0.0751)	…	…	(0.0750)	(0.0750)
Market-and-product-specific LBD$_{ijkt-1}$	0.0017**	0.0037*	0.0017**	0.0032	0.0017**	0.0037*	0.0017**	0.0032
	(0.0008)	(0.0020)	(0.0008)	(0.0020)	(0.0008)	(0.0020)	(0.0008)	(0.0019)
Market-and-product-specific LBD$^2_{ijkt-1}$	…	–0.0025	…	–0.0020	…	–0.0024	…	–0.0019
	…	(0.0018)	…	(0.0017)	…	(0.0018)	…	(0.0017)
Product-specific LBD$_{ikt-1}$	0.0041**	0.0123***	0.0049**	0.0127***	0.0041**	0.0123***	0.0049**	0.0127***
	(0.0020)	(0.0044)	(0.0020)	(0.0046)	(0.0019)	(0.0044)	(0.0020)	(0.0046)
Product-specific LBD$^2_{ikt-1}$	…	–0.0081**	…	–0.0077**	…	–0.0081**	…	–0.0077**
	…	(0.0035)	…	(0.0034)	…	(0.0035)	…	(0.0034)
Market-specific LBD$_{ijt-1}$	0.0012	0.0140***	0.0018	0.0135***	0.0012	0.0138***	0.0018*	0.0134***
	(0.0012)	(0.0045)	(0.0011)	(0.0043)	(0.0012)	(0.0046)	(0.0011)	(0.0044)
Market-specific LBD$^2_{ijt-1}$	…	–0.0131***	…	–0.0119***	…	–0.0128***	…	–0.0117***
	…	(0.0043)	…	(0.0040)	…	(0.0043)	…	(0.0039)
GDP per capita$_{it}$	…	…	…	…	$-8.8e^{-08}$	$-8.2e^{-08}$	$-1.1e^{-07}$	$-1.0e^{-07}$
	…	…	…	…	($8.2e^{-08}$)	($8.2e^{-08}$)	($7.7e^{-08}$)	($7.7e^{-08}$)
Openness$_{it}$	…	…	…	…	0.0001***	0.0001***	0.00007***	0.00007***
	…	…	…	…	(0.00003)	(0.00003)	(0.00002)	(0.00002)
GDP growth$_{it}$	…	…	…	…	0.0950***	0.0950***	0.0894***	0.0895***
	…	…	…	…	(0.0321)	(0.0321)	(0.0338)	(0.0338)
Constant	–0.0015	–0.0028*	–0.0014	–0.0025**	–0.0076***	–0.0088***	–0.0068***	–0.0079***
	(0.0014)	(0.0015)	(0.0009)	(0.0010)	(0.0023)	(0.0024)	(0.0020)	(0.0021)
Observations	853, 219	853, 219	853, 219	853, 219	853, 219	853, 219	853, 219	853, 219
Adjusted R^2	0.78	0.78	0.80	0.80	0.78	0.78	0.80	0.80

Note: Robust standard errors in parentheses. Clustered in export countries. Dummy variables for export country, import country, year, and product are included in all estimations; 1,003 product dummies are included.
* significant at 10%. ** significant at 5%. *** significant at 1%.

LBD converges to the upper bounds by 1.5, 2.2, and 1.5 standard deviations away from its means at the *market-and-product-specific*, *product-specific* and *market-specific* levels, respectively.[16] When 5-year changes in LBD are allowed at various levels of

$(\partial EXPPC/\partial LM|_{LM=.1887}) \cdot$ (*one standard deviation of LM*) $= 8.98 \times 10^{-3} \times 26.09 = 0.234$
0. 2344/(*one standard deviation of EXPPC*) = 0. 234/.21=1.1

16 *LMP*:
$(LMP|_{\partial EXPPC/\partial LMP=0}) = \beta_3/(2\beta_4) = .003/(2\times.0019) = 0.84$
$(LMP|_{\partial EXPPC/\partial LMP=0})$ - *Mean of LMP* = 0.84 - .29 = 0.55
0.54761/(*one standard deviation of LMP*)=0.55/.37=1.5

aggregation, LBD at the *product-specific* level is less bounded than at the other levels. The effects and potential of learning at the *product-specific* level on the export performance are stronger than those of LBD at the narrower *market-and-product-specific* level and at the *market-specific* level.

To further investigate these relationships, the sub-period time span is extended to ten years, and the following results are obtained. The narrowing of LBD to the world frontier level of LBD by 1 standard deviation at the *market-and-product-specific*, *product-specific*, and *market-specific* levels increases exports per-capita by 0.7 (17.2%,), 1.0 (22.7%) and 1.4 (29.7%) standard deviations, respectively. LBD converges to the upper bounds by 1.3, 3.3, and 1.2 standard deviations away from its mean at the *market-and-product-specific*, *product-specific* and *market-specific* levels, respectively. In addition, LBD at the narrower *market-and-product-specific* level turns out to have positive and statistically significant effects on export performance for all specifications.[17]

The present paper finds a positive but concave relationship between foreign trade and LBD at various levels of aggregation. Such relationship is stronger and less bounded at the *product-specific* level. A 1-standard deviation increase in the narrowing of LBD to the world frontier level of LBD at the *product-specific* level affects export performance by 26.6%, and the concave relationship remains positive until 2.2 standard deviations above the mean value of LBD at the *product-specific* level.

To determine whether or not this positive but concave relationship is robust to the longer time horizon of LBD, the sub-period time span is extended from 5 years to 10 years. As economies allow more meaningful changes in LBD, the concave relationship at the *product-specific* level remains positive, even with 3.3 standard deviations above the mean value of LBD. However, the effects of a 10-year change in LBD at the *market-specific* level on exports performance become stronger than at the *product-specific* level.

On the one hand, this may indicate that LBD at the *product-specific* level is not robust to the longer time horizon. The 10-year time horizon may make *market-specific* characteristics more flexible for redeployment from product to product.[18]

LP:

$(LP|_{\partial EXPPC/\partial LP=0}) = \beta_5/(2\beta_6) = .0127/(2\times.0077) = 0.82$

$(LP|_{\partial EXPPC/\partial LP=0})$ - *Mean of LP* = 0.82- .21 = 0.61

0.61408/(*one standard deviation of LP*)= 0.61/.28=2.2

LM:

$(LM|_{\partial EXPPC/\partial LM=0}) = \beta_7/(2\beta_8) = .0134/(2\times.0117) = 0.57$

$(LM|_{\partial EXPPC/\partial LM=0})$ - *Mean of LM* = 0.57- .19= 0.38

0.38395/(*one standard deviation of LM*)=0.38/.26=1.5

[17] The results can be provided upon request.

[18] Hausmann and Klinger (2007) show that the flexibility redeployed by the accumulated capabilities from product to product is related to the evolution of comparative advantage.

Thus, learning on non-tradable *market-specific* assets is more important than that on *product-specific* technology. On the other hand, the 10-year time horizon may not account correctly for the *product-specific* characteristics, and this measurement error underestimates the effects of LBD at the *product-specific* level on export performance. In short, these findings support the idea that countries with higher (lower) initial levels of LBD at the *product-specific* than at the narrower *market-and-product-specific* level tend to export more (less). Thus, with more meaningful changes over the longer time horizon, learning at the *market-specific* level may be more important than that at the *product-specific* level.

Economies with a higher LBD at the *product-specific* level may enhance the technological content of foreign trade and the transfer of technology, because technology and human capital are embodied in a product. The learning potential on industry-specific technology may dilute large fixed costs of exporting and explain the tendency to export a specific product to more countries. Thus, LBD at the *product-specific* level seems to affect export performance more significantly than learning at the other levels. However, institutions, infrastructure, property rights, regulations, or any public goods are relatively *market-specific* non-tradable assets. Exporting to a specific market over a longer period of time helps economies accumulate learning on the *market-specific* assets, transform their productive structures, and upgrade their export mix across products. Therefore, the learning process associated with the transition from learning about *product-specific* technology and human capital to learning about institutional *market-specific* assets is considered important to foreign trade flows.

4.2. Alternative Specifications and Robustness

Some outliers and heteroskedasticity may exist in the regressions. The cluster option is used for the exporting countries. Thus, the robust errors are obtained because it is possible that the exports within each exporting country may not be independent, and residuals may not be independent within the exporting countries. The observations are clustered into exporting countries, and the observations may be correlated within exporting countries but would be independent between exporting countries. Given that robustness is implied with clustering, data problems such as large residual, outlier and heteroskedasticity, are dealt with.

A 5-year gap is created between the initial cumulative export experience and the following export performance. Nonetheless, the dependent variable and the independent LBD variables are the flow exports amount and stock variables, respectively. In order to determine whether or not the estimates are sensitive to the period of the measures of cumulative per-capita exports, the LBD cumulative exports per-capita is measured with a 10-year gap. The effects of LBD at various levels of aggregation on the export performance are weaker than those with a 5-year gap. However, the export performance is positively related at a statistically significant level to the cumulative export experience at all export levels. The results confirm that the initial findings are robust to the alternative specifications.

In order to examine the possibility of a structural shift across the time periods, we conducted a pooled regression without year dummies. The results are similar to the initial findings, thus confirming the relationship between LBD and export performance.

Various sample selection strategies are also chosen. First, a tradeoff between the efficiency of the fixed effect estimation and the meaningful changes of the cumulative export experience may exist. We initially estimate the time span at the 5-year sub-period of exports per-capita and extend it to 10-year and reduce it to the 1-year in the regression Equation (4). In the 1-year data estimation of [Table 3], 20 random samples are drawn by randomly choosing 100 products out of the 1,003 products. The regression excludes the *market-specific* LBD variable because samples are drawn from the fixed set of products. The number of observations in the random sample is 800,000 on average. Of those 20 regressions, signs, and magnitudes of LBD coefficients are robust and consistent with respect to the initial findings. Second, initial levels of cumulative LBD are built by reducing the period from two decades to one decade, thus repeating the estimations. This also confirms the initial findings.

The cumulative per-capita export experience variables are built by adding the past flow export performance. It is possible that reverse causality exists, because countries with higher levels of exports tend to have more export experience. A 5-year gap is created between the last year of cumulative LBD variables and the first year of the following export performance.

To obtain results on reverse causality, the regressions are repeated by replacing the dependent variable with LBD variables at the respective levels of aggregation.[19] The effects of exports on learning at the *market-and-product-specific*, *product-specific*, and broader *market-specific* levels are not necessarily positive and significant at the 5% significance level. In [Table 4], we can see the results when LBD at the *market-and-product-specific* level is estimated as the dependent variable. The results are similar when the dependent variable is LBD at the *product-specific* or *market-specific* level.[20]

To control the autocorrelation problems associated with panel regressions, two-period lagged dependent variables are controlled. The present paper examines how the lagged dependent variable explains some cross-country variations of the

[19] In the related literature, Granger reverse causality tests are performed for bivariate variables or in the context of autoregressive distributed lag relationships (Hamilton 1994). We run dynamic nonlinear regressions, and the estimation in Equation (4) includes various quadratic LBD variables. Considering these characteristics, we employ reverse causality test that is in the line of Granger causality test. However, this test may not be able to sufficiently measure reverse causality.

[20] The results can be provided upon request.

dependent variable. We find that cumulative export experiences are consistent and robust to all the alternative specifications whether lagged dependent variables are excluded or included with one-period or two-period dependent variables.

[Table 4] Reverse Causality

	Market-and-product-specific LBD_{ijkt}							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Export performance$_{ijkt-1}$	0.0043	0.0042	0.0040	0.0039	0.0043	0.0042	0.0040	0.0040
	(0.0035)	(0.0032)	(0.0033)	(0.0035)	(0.0034)	(0.0032)	(0.0033)	(0.0031)
Market-and-product-specific	0.7342^{***}	0.9396^{***}	0.6863^{***}	0.8845^{***}	0.7342^{***}	0.9394^{***}	0.6862^{***}	0.8840^{***}
LBD_{ijkt-1}	(0.0180)	(0.0221)	(0.0275)	(0.0334)	(0.0180)	(0.0220)	(0.0275)	(0.0334)
Market-and-product-specific	…	…	0.0651^{***}	0.0578^{***}	…	…	0.0653^{***}	0.0580^{***}
LBD_{ijkt-2}	…	…	(0.0145)	(0.0137)	…	…	(0.0145)	(0.0137)
Market-and-product-specific	…	-0.2043^{***}	…	-0.1917^{***}	…	-0.2039^{***}	…	-0.1913^{***}
LBD^2_{ijkt-1}	…	(0.0193)	…	(0.0193)	…	(0.0192)	…	(0.0192)
Product-specific LBD_{ikt-1}	0.1075^{***}	0.1587^{***}	0.0998^{***}	0.1477^{***}	0.1073^{***}	0.1575^{***}	0.0997^{***}	0.1464^{***}
	(0.0100)	(0.01562)	(0.0082)	(0.0131)	(0.0100)	(0.0155)	(0.0081)	(0.0130)
Product-specific LBD^2_{ikt-1}	…	-0.0555^{***}	…	-0.0509^{***}	…	-0.0545^{***}	…	-0.0498^{***}
	…	(0.0096)	…	(0.0087)	…	(0.0095)	…	(0.0086)
Market-specific LBD_{ijt-1}	0.1208^{***}	0.1748^{***}	0.1135^{***}	0.1670^{***}	0.1210^{***}	0.1745^{***}	0.1136^{***}	0.1666^{***}
	(0.0118)	(0.0225)	(0.0098)	(0.0210)	(0.0117)	(0.0223)	(0.0097)	(0.0208)
Market-specific LBD^2_{ijt-1}	…	-0.0567^{***}	…	-0.0554^{***}	…	–0.0563	…	–0.0549
	…	(0.0189)	…	(0.0185)	…	(0.0187)	…	(0.0183)
GDP per capita$_{it}$	…	…	…	…	$-1.2e^{-06*}$	$-1.1e^{-06}$	$-1.2e^{-06*}$	$-1.1e^{-06}$
	…	…	…	…	$(6.2e^{-07})$	$(6.4e^{-07})$	$(6.4e^{-07})$	$(6.5e^{-07})$
Openness$_{it}$	…	…	…	…	0.0002^{***}	0.0002^{***}	0.0003^{***}	0.0003^{***}
	…	…	…	…	(0.0001)	(0.0001)	(0.0001)	(0.0001)
GDP growth$_{it}$	…	…	…	…	0.1091^{**}	0.1108^{**}	0.1078^{**}	0.1095^{**}
	…	…	…	…	(0.0502)	(0.0499)	(0.0534)	(0.0528)
Constant	0.0726^{***}	0.0541^{***}	0.0690^{***}	0.0518^{***}	0.0659^{***}	0.0473^{***}	0.0621^{***}	0.0449^{***}
	(0.0154)	(0.0154)	(0.0153)	(0.0155)	(0.0162)	(0.0162)	(0.0163)	(0.0164)
Observations	853, 218	853, 218	853, 218	853, 218	853, 218	853, 218	853, 218	853, 218
Adjusted R^2	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74

Note: Robust standard errors in parentheses. Clustered in export countries. Dummy variables for export country, import country, year, and product are included in all estimations; 1,003 product dummies are included.
* significant at 10%. ** significant at 5%. *** significant at 1%.

As argued by Young (1991), and empirically shown by Fernandes and Isgut (2005), learning by exporting can take place through cumulative export experience rather than export participation and repetition. The relative LBD variables are built based upon the cumulative volume of per-capita exports. To test whether or not the effects of LBD measured by the cumulative volume of export experience are sensitive to the frequency of export participation, cumulative export participation count variables are built by adding the number of times an economy exports during a particular period at various export levels. Cumulative count variables of export participation are built as follows:

(1) *Market-and-product-specific export participation*$_{ijkt}$ in Equation (5) is a cumulative export participation count variable of country *i*, which exports product *k* to country *j* in year *t*. It is the total number of export participation measured in number of years a country *i* has exported at the *market-and-product-specific* level. The unit of the *market-and-product-specific* cumulative dummy variable for export participation is year.

$$\begin{aligned} &\textit{Market-and-product-specific export participation}_{ijkt} = \textstyle\sum_{\tau=1}^{t} d_{ijk\tau} \\ &\textit{where } d_{ijk\tau} = 1 \textit{ if export performance}_{ijk\tau} > 0 \\ &\qquad\quad = 0 \textit{ otherwise} \end{aligned} \tag{5}$$

(2) *Product-specific export participation*$_{ikt}$ in Equation (6) is a cumulative export participation count variable of country *i*, which exports product *k* to the entire world in year *t*. It is the total number of export participation measured in number of times a country *i* has exported to the entire world at the *product-specific* level. The unit of the *product-specific* cumulative dummy variable for export participation is market.

$$\begin{aligned} &\textit{Product-specific export participation}_{ikt} = \textstyle\sum_{\tau=1}^{t} \sum_{j=1}^{J} d_{ijk\tau} \\ &\textit{where } d_{ijk\tau} = 1 \textit{ if export performance}_{ijk\tau} > 0 \\ &\qquad\quad = 0 \textit{ otherwise} \end{aligned} \tag{6}$$

(3) *Market-specific export participation*$_{ijt}$ in Equation (7) is a cumulative export participation count variable of country *i*, which exports all products to country *j* in year *t*. It is the total number of export participation measured in number of times a country *i* has exported all products at the broader *market-specific* level. The unit of the *market-specific* cumulative dummy variable for export participation is product.

$$\begin{aligned} &\textit{Market-specific export participation}_{ijt} = \textstyle\sum_{\tau=1}^{t} \sum_{k=1}^{K} d_{ijk\tau} \\ &\textit{where } d_{ijk\tau} = 1 \textit{ if export performance}_{ijk\tau} > 0 \\ &\qquad\quad = 0 \textit{ otherwise} \end{aligned} \tag{7}$$

The cumulative export participation count variables are included in the estimation (4). First, these cumulative count variables are linearly added to the regression Equation (4), and all the estimations are repeated. The effects of LBD measured by the frequency of export participation on the export performance are not necessarily positive and robust. On the other hand, the effects of LBD at various levels of aggregation measured by the cumulative volume of export experience (*market-and-product-specific LBD*, *product-specific LBD*, and *market-specific LBD*) are consistent and robust, and all the results confirm the initial findings. Second, the cumulative count variables are nonlinearly added to the regression Equation (4) by creating the squared cumulative count variables. The results shown in [Table 5] confirm that the initial findings are robust, even after nonlinearly controlling for the frequency of export participation. The results support the idea that LBD in foreign trade affects export performance not merely through the frequency of export participation but also through the cumulative volume of per-capita export experience.

[Table 5] Panel Data OLS Estimates with Cumulative Export Participation Variables

	Export performance$_{ijkt}$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Export performance$_{ijkt-1}$	0.9244^{***}	0.9244^{***}	1.175^{***}	1.175^{***}	0.9244^{***}	0.9244^{***}	1.175^{***}	1.175^{***}
	(0.0624)	(0.0624)	(0.1153)	(0.1154)	(0.0624)	(0.0624)	(0.1153)	(0.1153)
Export performance$_{ijkt-2}$	…	…	-0.3194^{***}	-0.3194^{***}	…	…	-0.3193^{***}	-0.3193^{***}
	…	…	(0.0751)	(0.0751)	…	…	(0.0750)	(0.0750)
Market-and-product-specific	0.0013^{*}	0.0028	0.0014^{*}	0.0023	0.0012^{*}	0.0024	0.0013^{*}	0.0019
LBD$_{ijkt-1}$	(0.0007)	(0.0020)	(0.0007)	(0.0019)	(0.0007)	(0.0020)	(0.0007)	(0.0019)
Market-and-product-specific	…	–0.0019	…	–0.0012	…	–0.0015	…	–0.0010
LBD$^2_{ijkt-1}$	…	(0.0018)	…	(0.0017)	…	(0.0018)	…	(0.0018)
Market-and-product-specific	0.00002	$-1.4e^{-06}$	0.00012	0.0001	$-1.3e^{-06}$	$-1.5e^{-05}$	0.0001	0.0001
export participation$_{ijkt-1}$	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.00007)	(0.00007)	(0.00009)	(0.00009)
Market-and-product-specific	$-1.4e^{-07}$	$2.5e^{-07}$	$-1.3e^{-06}$	$-9.3e^{-07}$	$1.1e^{-07}$	$4.5e^{-07}$	$-1.0e^{-06}$	$-7.4e^{-07}$
export participation$^2_{ijkt-1}$	$(1.5e^{-06})$	$(1.5e^{-06})$	$(1.8e^{-06})$	$(1.7e^{-06})$	$(1.6e^{-06})$	$(1.6e^{-06})$	$(1.9e^{-06})$	$(1.8e^{-06})$
Product-specific LBD$_{ikt-1}$	0.0038^{*}	0.0119^{**}	0.0047^{**}	0.0123^{**}	0.0038^{*}	0.0119^{**}	0.0047^{**}	0.0123^{**}
	(0.0020)	(0.0046)	(0.0020)	(0.0047)	(0.0020)	(0.0046)	(0.0020)	(0.0047)
Product-specific LBD$^2_{ikt-1}$	…	-0.0079^{**}	…	-0.0074^{**}	…	-0.0078^{**}	…	-0.0074^{**}
	…	(0.0037)	…	(0.0035)	…	(0.0037)	…	(0.0036)
Product-specific export	$2.5e^{-06**}$	$1.9e^{-06*}$	$1.5e^{-06}$	$9.7e^{-07}$	$2.1e^{-06**}$	$1.5e^{-06}$	$1.2e^{-06}$	$6.6e^{-07}$
participation$_{ikt-1}$	$(1.1e^{-06})$	$(1.1e^{-06})$	$(1.2e^{-06})$	$(1.2e^{-06})$	$(1.0e^{-06})$	$(1.1e^{-06})$	$(1.2e^{-06})$	$(1.2e^{-06})$
Product-specific export	$-7.9e^{-10**}$	$-6.8e^{-10**}$	$-6.7e^{-10*}$	$-5.8e^{-10*}$	$-4.6e^{-10}$	$-3.7e^{-10}$	$-4.0e^{-10}$	$-3.2e^{-10}$
participation$^2_{ikt-1}$	$(3.2e^{-10})$	$(3.2e^{-10})$	$(3.4e^{-10})$	$(3.4e^{-10})$	$(3.3e^{-10})$	$(3.3e^{-10})$	$(3.4e^{-10})$	$(3.5e^{-10})$
Market-specific LBD$_{ijt-1}$	–0.0002	0.0120^{***}	0.0010	0.0128^{***}	–0.0006	0.0106^{***}	0.0006	0.0116^{***}
	(0.0010)	(0.0041)	(0.0010)	(0.0043)	(0.0010)	(0.0040)	(0.0010)	(0.0042)
Market-specific LBD$^2_{ijt-1}$	…	-0.0119^{***}	…	-0.0115^{***}	…	-0.0110^{***}	…	-0.0107^{***}
	…	(0.0042)	…	(0.0040)	…	(0.0040)	…	(0.0039)
Market-specific export	$3.3e^{-07}$	$1.5e^{-07}$	$1.2e^{-07}$	$-4.4e^{-08}$	$3.6e^{-07}$	$2.0e^{-07}$	$1.6e^{-07}$	$5.9e^{-09}$
participation$_{ijt-1}$	$(2.3e^{-07})$	$(2.4e^{-07})$	$(2.1e^{-07})$	$(2.4e^{-07})$	$(2.3e^{-07})$	$(2.5e^{-07})$	$(2.1e^{-07})$	$(2.4e^{-07})$

Market-specific export participation$^2_{ijt-1}$	$-2.7e^{-12}$	$2.8e^{-12}$	$-4.6e^{-13}$	$4.9e^{-12}$	$2.0e^{-12}$	$6.6e^{-12}$	$3.1e^{-12}$	$7.7e^{-12}$
	$(1.3e^{-11})$	$(1.4e^{-11})$	$(1.2e^{-11})$	$(1.3e^{-11})$	$(1.4e^{-11})$	$(1.4e^{-11})$	$(1.2e^{-11})$	$(1.3e^{-11})$
GDP per capita$_{it}$	…	…	…	…	$-1.9e^{-07**}$	$-1.7e^{-07*}$	$-1.7e^{-07*}$	$-1.5e^{-07*}$
	…	…	…	…	$(9.3e^{-08})$	$(9.0e^{-08})$	$(8.5e^{-08})$	$(8.1e^{-08})$
Openness$_{it}$	…	…	…	…	0.0001***	0.0001***	0.00007***	0.00007***
	…	…	…	…	(0.00003)	(0.00003)	(0.00002)	(0.00002)
GDP growth$_{it}$	…	…	…	…	0.0969***	0.0965***	0.0903***	0.0899***
	…	…	…	…	(0.0321)	(0.0321)	(0.0339)	(0.0338)
Constant	–0.0015	–0.0024	–0.0023**	–0.0032***	–0.0069***	–0.0078***	–0.0072***	–0.0081***
	(0.0016)	(0.0016)	(0.0011)	(0.0012)	(0.0023)	(0.0024)	(0.0020)	(0.0021)
Observations	853, 219	853, 219	853, 219	853, 219	853, 219	853, 219	853, 219	853, 219
Adjusted R^2	0.78	0.78	0.80	0.80	0.78	0.78	0.80	0.80

Note: Robust standard errors in parentheses. Clustered in export countries. Dummy variables for export country, import country, year, and product are included in all estimations. 1003 product dummies are included.
* significant at 10%. ** significant at 5%. *** significant at 1%.

V. Conclusions

Economies tend to export more if they accumulate greater learning experience at the *product-specific* level. This paper provides new evidence for this view by looking at a comprehensive NBER-United Nations dataset on exports, which covers 130 countries and 1,003 product categories between 1962 and 2000. Using the data set, this paper finds a positive but concave relationship between the current level of export performance and the lagged cumulative export experience at various export levels, even though there is little evidence between the current level of export performance and the lagged cumulative export participation. The relationship is robust even after controlling for country income effects, openness, per-capita GDP growth rates as well as country fixed, product fixed, and time fixed effects.

The positive but concave relationship between foreign trade and LBD is stronger and less bounded at the *product-specific* level. The narrowing of LBD to the world frontier level of LBD by 1-standard deviation at the *product-specific* level increases exports per-capita by 26.6%. However, LBD at the *market-specific* level, with more meaningful changes, becomes more important than at the *product-specific* level over longer time horizon. These findings raise two questions. Why does LBD at the *product-specific* level have positive significant explanatory power? Moreover, through which mechanisms can the effects of LBD at the *market-specific* level on export performance be stronger than at the *product-specific* level?

The answer to the first question is comparable with the models of fixed costs of exporting to more markets. The idea that learning potential on *product-specific* technology may dilute large fixed costs of exports has been proven by numerous works. First, An and Iyigun (2004a) find that economies with a higher level of learning by exporting enhance export technology content in foreign trade. Second, Hummels and Klenow (2005) empirically test how exports vary with a country's size, and provide evidence that the extensive export margin associated with the models of fixed costs of exports explains the tendency to export a specific product (and more varieties) to more markets. The present paper contributes to these studies by adding that LBD at the *product-specific* level affects export performance more significantly than learning at the other levels.

The second issue is to identify mechanisms, through which the effects of LBD at the *market-specific* level on export performance becomes stronger than at the *product-specific* level. The assembled evidence supports many previous findings. For instance, *market-specific* institutional factors become more flexible for redeployment from product to product if LBD is accumulated at the *market-specific* level (Hausmann et al. 2007). Institutional assets change very slowly over time. The seemingly time-invariant structures would be transformed with larger *market-specific* LBD over a longer period of time. Moreover, this helps economies create more sophisticated export mixes.

A model that incorporates learning process associated with the transition from learning about *product-specific* technology and human capital to learning about *market-specific* institutional assets can strengthen the framework for determining foreign trade flows. Analyzing the dynamics of LBD at the *product-specific* and *market-specific* levels in relation to structural transformation can help explain its effects on the future export performance and development paths of an economy.

References

An, G., and M. Iyigun (2004a), "The Export Technology Content, Learning by Doing and Specialization in Foreign Trade," *Journal of International Economics*, 64, 465-83.

__________________ (2004b), "The Export Skill Content, Learning by Exporting and Economic Growth," *Economics Letters*, 84, 29-34.

Bernard, A. B., and J.B. Jensen (1999), "Exceptional Exporter Performance: Cause, Effect, or Both?" *Journal of International Economics*, 47, 1-26.

Besedes, T., and T.J. Prusa (2007), "The Role of Extensive and Intensive Margins and Export Growth," NBER Working Paper No. 13628, NBER.

Brander, J. A., and B. J. Spencer (1985), "Export Subsidies and International Market Share Rivalry," *Journal of International Economics*, 18, 83-100.

Chuang, Y. (1998), "Learning by Doing, the Technology Gap, and Growth," *International Economic Review*, 39(3), 697-721.

De Loecker, J. (2007), "Do Exports Generate Higher Productivity? Evidence from Slovenia," *Journal of International Economics*, 73, 69-98.

Feenstra, R. C., and A. K. Rose (2000), "Putting Things in Order: Trade Dynamics and Product Cycles," *Review of Economics and Statistics*, 82(3), 369-82.

Feenstra, R. C., R. E. Lipsey, H. Deng, A. C. Ma, and H. Mo (2005), "World Trade Flows: 1962-2000," NBER Working Paper No. W11040, NBER.

Fernandes, A. M., and A. E. Isgut (2005), "Learning-by-Doing, Learning-by-Exporting, and Productivity: Evidence from Colombia," World Bank Working Paper No. 3544.

Hamilton, J. D. (1994), *Time Series Analysis*. NJ: Princeton University Press.

Hausmann, R., J. Hwang, and D. Rodrik (2007), "What You Export Matters," *Journal of Economic Growth*, 12, 1-25.

Hausmann, R., and B. Klinger (2007), "The Structure of the Product Space and the Evolution of Comparative Advantage," Harvard Centre for International Development Working Paper No. 146.

Heston, A., R. Summers, and B. Aten (2006), Penn world table version 6.2. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

Hidalgo, C. A., B. Klinger, A. L. Barabasi, and R. Hausmann (2007), "The Product Space Conditions the Development of Nations," *Science*, 317(5837), 482-7.

Hummels, D., and P. J. Klenow (2005), "The Variety and Quality of a Nation's Exports," *American Economic Review*, 95(3), 704-23.

Jovanovic, B., and Y. Nyarko (1996), "Learning by Doing and the Choice of Technology," *Econometrica*, 64(6), 1299-1310.

Keller, W. forthcoming (2009), "Transfer of Technology," In *New Palgrave dictionary of economics*, 2nd ed., ed. L. E. Blume and S. N. Durlauf, London: MacMillan.

Melitz, M. (2005), "When and How Should Infant Industries be Protected?" *Journal of International Economics*, 66, 177-196.

Ohashi, H. (2005), "Learning by Doing, Export Subsidies, and Industry Growth: Japanese

Steel in the 1950s and 1960s," *Journal of International Economics*, 66, 297-323.

Pavcnik, N. (2002), "Trade Disputes in the Commercial Aircraft Industry," *World Economy*, 25, 733-751.

Van Biesebroeck, J. (2005), "Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms," *Journal of International Economics*, 67, 373-391.

Yoon, S.-C. (2005). "Endogenous Technology Gap with North-South Trade," *Korean Economic Review*, 21(2), 255-276.

Young, A. (1991), "Learning by Doing and the Dynamic Effects of International Trade," *Quarterly Journal of Economics*, 106(2), 369-05.

________ (1993), "Invention and Bounded Learning by Doing," *Journal of Political Economy*, 101, 443-72.