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SURVIVAL ANALYSIS OF THE EXPORTS OF LEAST DEVELOPED COUNTRIES: THE ROLE OF COMPARATIVE ADVANTAGE

POLICY ISSUES IN INTERNATIONAL TRADE AND COMMODITIES
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by

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Abstract

Motivated by the standard Heckscher-Ohlin theory, we investigate whether comparative advantage affects the duration of exports from least developed countries (LDCs). To do so, we first calculate each exported product's distance from the country's comparative advantage. Then we estimate a semi-parametric Extended Cox model with time-independent/dependent explanatory variables to measure export survival rates. We find evidence that a product's distance to comparative advantage is a determinant of export survival for LDCs. Moreover, we find that the influence of comparative advantage over LDC export survival increases with time. This implies that exports of products that are close to the country's comparative advantage are likely to be more durable. In the long run, comparative advantage can evolve dynamically. Export diversification by LDCs into non-traditional sectors calls for vigorous investment to improve the quantity and the quality of their factor endowments.

Keywords: Export diversification, comparative advantage, LDCs

JEL Classification: F11

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1. Introduction

Export diversification has long been instrumental to the successful development of emerging economies, as it creates a broad base for export-led growth. For a large number of least developed countries (LDCs), however, export diversification has been a chimera. Exports of LDCs are still largely concentrated in very few sectors and are often limited to primary commodities. Diversification, or the lack of it, is reflected in the statistics. The index of export concentration (Herfindahl–Hirschmann) for LDCs has been increasing over the past 10 years. In 2009, the concentration of exports of LDCs was about four times as large as that of developing economies as a whole.[1]

The lack of technological capacity to produce a wide variety of products and Dutch disease symptoms may have been the major cause for export concentration in many LDCs. Moreover, even after a country begins to export a non-traditional product, empirical evidence indicates that sustaining the diversification in a way that ensures the continuing flow of new exports is not an easy task. On average, an export spell – or the duration of a product being exported to a particular market – is short: just one year for exports from LDCs and two years for other developing countries and developed countries. Besedes and Prusa (2006a, 2006b) showed that half of exports to the market of the United States of America did not survive longer than two years. Similar tendency has been found in other studies such as Nitch (2009) for German exports; Carballo and Volpe (2008) for Peruvian exports; Alvarez and Fuentes (2009) for Chilean exports; Eaton, Eslava, Kugler and Tybout (2008) for Colombian exports; and Gorg, Kneller and Murakozy (2008) for Hungarian exports. That is, to achieve successful export diversification, we should focus on how to make new exports survive in the international market.

In the economic literature, a number of studies looked into the patterns of export duration and possible determinants of the survival of exports in their respective markets. Such studies show that the likelihood of the survival of exports widely varies across sectors as well as across different levels of development of exporters. Besedes and Prusa (2006a) find exports from industrial countries last significantly longer than those from developing countries.

Our data suggest the same: Bilateral trade flows are characterized by lack of continuity. An export spell – the number of continuous years during which a particular product was exported from a LDC to an importing market – is of short duration, often lasting only for one or two years.[2] The short duration of export spells is common across all countries, but particularly so for the exports of LDCs. The median survival time of exports from LDCs is just one year, compared with two years of exports from developed and developing countries. That is, at least half of the exports LDCs do not last more than one year. The incidence rate (the rate of a product stops being exported during the studied period) of LDCs is high at 41 per cent (table 1.1).

[1] UNCTADStat.

[2] The export products are classified at the six-digit level of the Harmonized Commodity Description and Coding System (HS).

Table 1.1. Export termination incidence rate

	Number of subjects	*Incidence rate (per cent)*	*Median Survival Time*	
			Uncensored observations	*Censored observations*
Developed countries	7 785 638	13	2	4
Developing countries	5 313 635	15	2	3
LDCs	245 840	41	1	1

Note: Authors' own calculations.

To further investigate the patterns of the survival of LDCs' exports, we look into export flows of 17 LDCs to 190 importing countries during a period of 14 years (1993–2007).[3] As is standard in survival analysis, we convert annual trade data into export spells.[4] For example, Benin's export of cotton to Austria from 1994 to 2002 without a break constitutes one spell with the length of nine years. The total number of time periods for which exports are observed is 464,251, which corresponds to 245,840 exporting spells of various lengths.[5]

Table 1.2 provides the summary statistics of 17 LDCs. Forty-one per cent of the observed export spells of all the studied LDCs ended during the sample period. The highest incidence rate of exports observed is 67 per cent for the Gambia and the lowest is 29 per cent for Bangladesh. The mean length of a spell for the whole sample is 1.88 year. Longer spells are observed in two Asian countries (Bangladesh and Nepal), and the lowest is found in the Gambia, Liberia and Rwanda. The median spell length is 1 across all LDCs in the sample, which means at least half of exports from each country did not last longer than one year during the studied period. The export duration at the 75th percentile varies between one year for the Gambia and six years for Bangladesh.

So what determines the duration of exports of the export survival in the international market? Brenton, Saborowski and von Uexkull (2009) show that learning-by-doing reduces the risk of short life of exports from developing countries. Fugazza and Molina (2009) find that high fixed costs linked to trade reduces the rate of survival of exports. Jaud, Kukenova and Strieborny (2009) find that exports that do not bear a country's comparative advantage (e.g. labour-intensive products in a capital-abundant country) survive shorter in the United States market.

This study investigates whether there is any interaction between the Heckscher–Ohlin theorem and the chances of export survival. That is, we examine if a difference between a product's factor intensity and the exporting country's factor endowments – or comparative advantage – would have any impact upon the export duration of the product concerned.

[3] For export statistics, we use mirror data from importing countries extracted from the UNCTAD South–South Trade Information System. The 17 LDCs are selected on the basis of data availability.

[4] Some of the available data required left- or right-censoring. Left-censoring implies that we exclude all the spells that are observed in 1993 from the analysis, as we do not know how long these exports had been in existence prior to 1993. Similarly, with regard to right-censoring, we do not know how long the exports that are observed in the final year would continue to exist. The estimation technique of survival methods will take care of this right-censoring.

[5] Whenever the interval between spells is just one year, there is a high probability of misreporting, i.e. trade is not reported for that year. We correct this measurement error by merging spells with a one-year gap.

Table 1.2. Survival duration of least developed countries' exports, by country

Exporters	*Total analysis time at risk*	*Incidence rate (per cent)*	*Number of subjects (spells)*	*Survival time (year)*		
				*Mean**	*Median*	*At 75th percentile*
Benin	16 406	50	9 220	1.78	1	2
Bangladesh	113 636	29	46 770	2.43	1	6
Central African Republic	6 706	61	4 845	1.38	1	2
Gambia	8 989	67	6 607	1.36	1	1
Liberia	7 556	63	5 589	1.35	1	2
Mali	21 001	55	13 570	1.55	1	2
Mozambique	18 320	47	10 870	1.69	1	3
Malawi	16 309	46	9 314	1.75	1	3
Niger	14 749	61	10 601	1.39	1	2
Nepal	59 220	31	25 354	2.34	1	4
Rwanda	5 405	62	4 036	1.34	1	2
Sudan	15 601	54	10 173	1.53	1	2
Senegal	51 777	40	27 220	1.90	1	3
Sierra Leone	22 186	54	14 589	1.52	1	2
Togo	34 114	41	17 134	1.99	1	3
Uganda	26 764	42	15 136	1.77	1	3
Zambia	25 512	45	14 812	1.72	1	3
Total	**464 251**	41	**245 840**	**1.88**	**1**	**3**

Notes: * uncensored observations
Authors' own calculations.

The rest of this paper is organized as follows: Chapter 2 discusses the results derived from our empirical analysis; chapter 3 concludes with some policy suggestions to LDCs.

2. Survival analysis findings

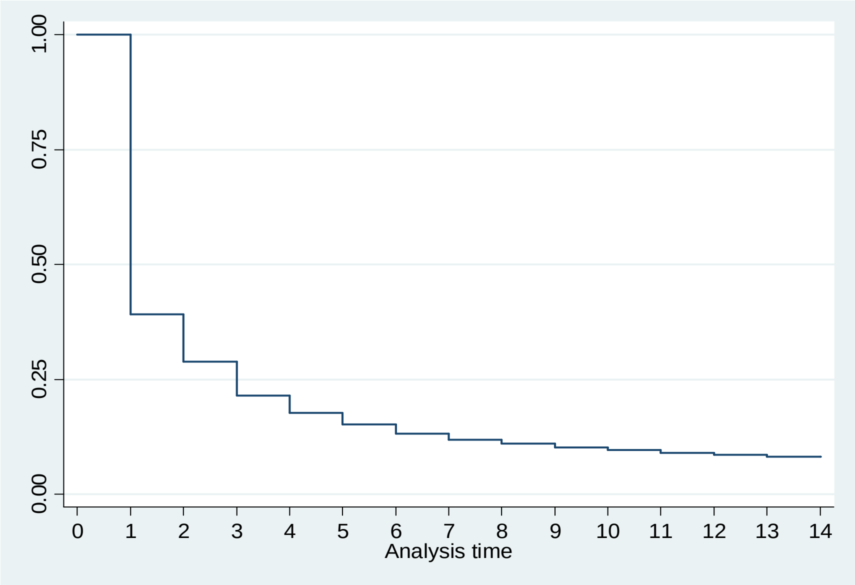
The object of interest in survival analysis is the length of spells and the identification of the factors that make spells end. The survival analysis allows us to focus on the long-term sustainability of trade relationships rather than year-to-year changes in the trade volumes and to examine the relationship between the survival time and some covariates, i.e. factors that may influence the survival.

In this study, we use two survival models. First, we use the Kaplan–Meier survival function to examine general patterns of the survival of exports of LDCs. The survival function gives the probability of a trade relationship (e.g. exports) surviving past a given time t. Second, we use the Extended Cox Proportional Hazard model to examine the degree of influence of the independent variables on the export survival. A detailed explanation of the models we use is given in the annex.

2.1. Estimated survival pattern of least developed countries' exports (Kaplan–Meier analysis)

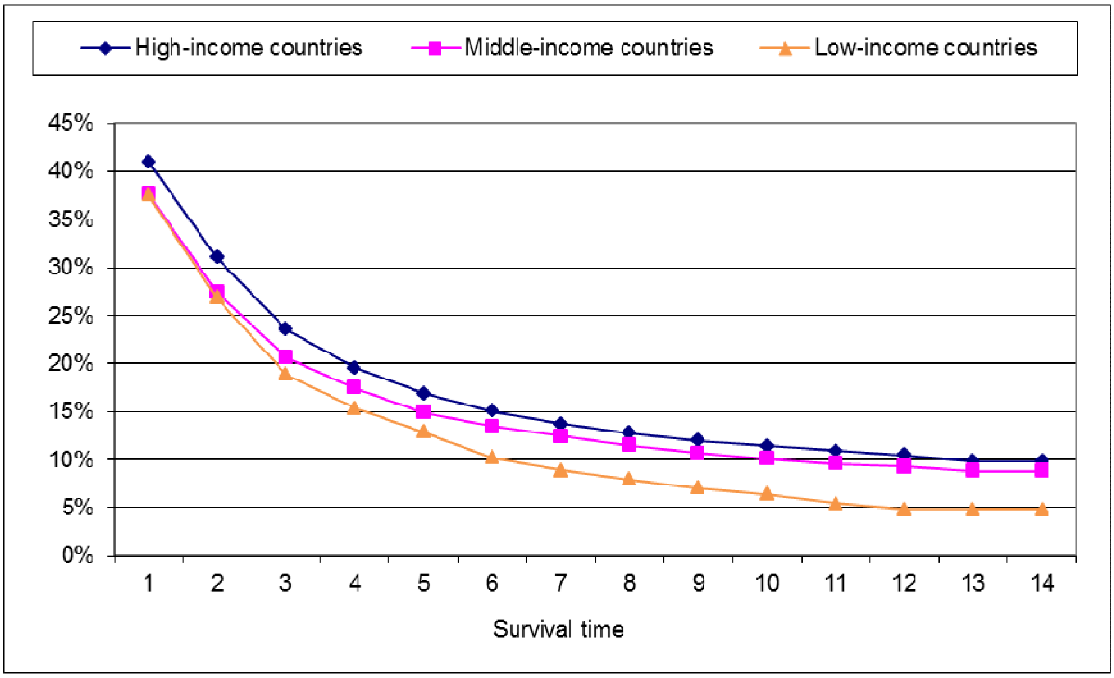
The Kaplan–Meier analysis on export spells of 17 LDCs suggest that more than 60 per cent of the sample is likely to disappear after the first year of exporting (figure 2.1). Only 8 per cent is estimated to survive to the end of the studied period.

Figure 2.1. Kaplan–Meier survival estimates for least developed countries' exports



However, the estimated length of export survival changes when the export spells are grouped according to the market destination: (a) high-income countries; (b) middle-income countries, and (c) low-income countries. As shown in figure 2.2, LDC exports to high-income countries have higher survival rates than those to developing countries (i.e. middle- and low-income countries). Over 40 per cent of the exports to high-income countries on average survive more than one year, while only 37 per cent of the exports to low-income countries survive after the first year. This outcome could be due to a combination of different reasons, including a different composition of the LDC export basket to different markets, import demand being more stable in higher-income countries than developing countries and preferential market access conditions granted to LDCs' exports in high-income countries.

Figure 2.2. Survival functions by export destination



2.2. Factors influencing the survival of least developed countries' exports (Extended Cox Proportional Hazards Model)

We turn to examining the factors that are likely to influence the likelihood of export survival. We are particularly interested in the degree of influence, if any, of comparative advantage of a country over a product's export survival.

Our choice of covariates, i.e. factors that may determine the likelihood of the survival of exports, are as follows: an exported product's distance from the country's comparative advantage, the degree of market diversification, the degree of product diversification, initial export values and the variables commonly included in the trade gravity model. These covariates are explained below.

(a) Distance from comparative advantage

The key variable of interest is the distance from the exporting country's comparative advantage at the time when the product is exported. This is calculated as the Euclidian distance between (a) the country's factor endowments in human capital, physical capital and natural resources of the exported year; and (b) the product's revealed factor intensity (RFI), using the RFI indices developed by Cadot, Shirotori and Tumurchudur (2010).[6] A product is "distanced" from a country's comparative advantage when the product is not utilizing the factor endowment that is relatively abundant in the country, or only utilizing the factor endowment that are relatively scarce in the country. The methodology to calculate a product's distance from comparative advantage is given in the appendix.

(b) Market diversification and product diversification

Export survival would also depend on specific export capability of countries, which can be measured by the degree of market diversification or product experience and product diversification or market experience. Volpe and Carballo (2008), using disaggregated firm-level export data of Peru for the period 2000–2006, find that both market diversification (i.e. exporting the same products to many buyers) and product diversification (i.e. exporting many products to the same buyer) increase the chances of surviving in foreign export markets. Cadot, Iacovone, Rauch and Pierola (2010) also find that a firm's product experience and market experience matter for export survival. They used the number of destinations to which the firm already exports that product as a proxy to product experience, and the number of products the firm already exports to that market as market experience.

We control for market and product diversification in a similar way, but only at the national level. Market diversification (or product experience) is measured by the number of importing markets for a particular product exported by a country, and product diversification (or market experience) is measured by the number of products that are exported by a country to a particular market.

[6] Based on Cadot, Shirotori and Tunurchudur (2008), UNCTAD constructed a database of revealed factor intensity indices (RFII) of products at the HS 6-digit level of product classification. RFII approximates the revealed factor content of a product as a weighted average of the national factor endowments of countries that export the product, the weights being these exporters' revealed comparative advantage indices. The database contains three indices of RFI: Revealed physical capital intensity index, revealed human capital intensity index and revealed natural resource intensity database. The database also includes the updated country endowment data (capital stocks per worker, average years of schooling and arable land per worker) for a cross-section of 137 countries (countries that have all three endowments) for the period 1961–2007. The database can be freely accessed online at http://www.unctad.info/en/Trade-Analysis-Branch.

(c) Initial export values

Initial export values, i.e. the value of exports at the start of export spells, is a proxy to the level of confidence between the trading partners. We expect that the higher the initial trade value of the export, the higher the likelihood of the export to survive.

(d) Other gravity variables

We included the variables commonly used in a gravity model as the covariates in the model. These are the following: exporting country's gross domestic product (GDP) per capita; importing country's GDP per capita; geographical distance between the exporter and the importer: a dummy for a common border; and a dummy for common language. The coefficients on these variables are expected to be in line with those typically found in gravity model regressions.

Table 2.1 shows the results derived from different semiparametric Cox models with time-fixed effects to control for year-specific conditions that might influence export survival. Before discussing the results, some discussion on the interpretation of coefficient is in order. A coefficient above one implies that a positive correlation between the hazard rate and changes in a covariate. A unit increase in the covariate would result in an increase in the hazard rate, i.e. export survival becomes less likely. A coefficient below one implies a negative correlation, i.e. a unit increase in the covariate results in a longer export survival.

As mentioned at the outset, this study is particularly interested in possible interaction between the Heckscher–Ohlin theorem and the chances of export survival. That is, we examine if an exported product based on the country's comparative advantage (e.g. intensively using input factors that are relatively abundant in the country) would have a better chance to survive in the international market.

The estimation result finds a coefficient on the distance to comparative advantage being greater than one. This implies that, as a product becomes farther away from the exporting country's comparative advantage, the hazard rate becomes higher so the export survival period becomes shorter.

The survival rate also depends on supply capacity of the exporting country. As discussed above, these are captured by two variables: market diversification and product diversification. The coefficients on these variables are below one and statistically significant. This implies that the hazard rate decreases as a country becomes more diversified in markets and/or products.

In line with other previous studies, the gravity-model-motivated variables have the expected signs. Exporting countries with larger GDP (exporter GDP), countries exporting to larger economies (importer GDP), those having a common language (dummy for common language) or sharing a border with a trading partner (dummy for border) all reduce the hazard rate of exporting, i.e. increase the likelihood of export survival. As the geographical distance to the trading partners (physical distance) increases, the hazard of exporting increases due to the increase in the transport-related costs.

Table 2.1. Results derived from semiparametric Cox model with gravity-type variables

	Model 1	*Model 2*
Distance to comparative advantage (log)	1.035***	1.019**
	(0.008)	(0.008)
Market diversification (log)		0.811***
		(0.005)
Product diversification (log)		0.883***
		(0.002)
Initial export (log)	0.959***	0.959***
	(0.001)	(0.001)
Exporter GDP (log)	0.905***	1.032***
	(0.009)	(0.008)
Importer GDP (log)	0.953***	0.991***
	(0.002)	(0.002)
Physical distance (log)	1.032***	0.978***
	(0.005)	(0.004)
Dummy for common language	0.945***	0.950***
	(0.006)	(0.005)
Dummy for border	0.751***	0.823***
	(0.007)	(0.008)
Multispell	1.101***	1.194***
	(0.008)	(0.01)
Fixed effect by year	Yes	Yes
Stratified by HS 6-digit	Yes	Yes
Number of observations	140 385	140 385
Wald chi2	2 176 796	2 505 962
Log pseudolikelihood	- 380 077	- 378 103

Notes: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Besides gravity variables, the models also control for the starting level of confidence between the trading partners. This is done by adding the initial value of export as a control variable. The result indicates that the higher is the original confidence of the trading partners the longer the export duration.

In the results of table 2.1 above, country-specific characteristics and trade costs are controlled for by gravity- type variables. In order to check the robustness of the result, i.e. to better control for a wide array of observable and unobservable characteristics of the exporting and the importing countries that might affect the hazard rate, we estimate the model with the inclusion of fixed effects by exporter and importer on the same sample. The results are reported in table 2.2. An additional advantage of the use of fixed effects is that it allows to considerably extending the dataset, as it does not require GDP data, which are not always available for our set of LDCs. Sample selection does not appear to affect the overall results as the coefficients of the variables of interest are very similar.

The results presented so far treat the covariates as time-independent. That is, the results represent a kind of average effects over the observation period. However, the effect arising from changes in the covariates may be time-variant. We now examine whether the impact of covariates on export survival changes through time by splitting the data at every observed failure time, i.e. at every export year and for each spell. This enables us to estimate the Cox model with the changing effects of covariates through time.

Table 2.2. Results derived from semiparametric Cox model

	Model 1	*Model 2*
Distance to comparative advantage (log)	1.026***	1.012**
	(0.006)	-(0.005)
Market diversification (log)		0.819***
		-(0.004)
Product diversification (log)		0.899***
		-(0.002)
Initial export (log)		0.959***
		-(0.001)
Multispell		1.154***
		-0.007
Fixed effect by		
exporter	Yes	Yes
importer	Yes	Yes
year	Yes	Yes
Stratified by		
HS 6-digit	Yes	Yes
Observations	245 840	245 840
Log pseudolikelihood	-780 549	-777 626

Notes: Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

The results derived from the Cox regression with time-varying covariates are presented in table 2.3. The initial effect of the distance to comparative advantage on export survival at the very start of an export spell (time t_0) now loses its significance. However, the interaction terms, i.e. the changing effects of covariates through time, are all significant at the 0.01 level, which confirms the violation of proportional hazard assumption for the covariates. The coefficient of the distance to comparative advantage interacted with time is above one. This implies that the impact of the distance from comparative advantage over the hazard rate increases (or its impact upon export survival decreases) through time.

Table 2.3. Results derived from Cox model with time interactions

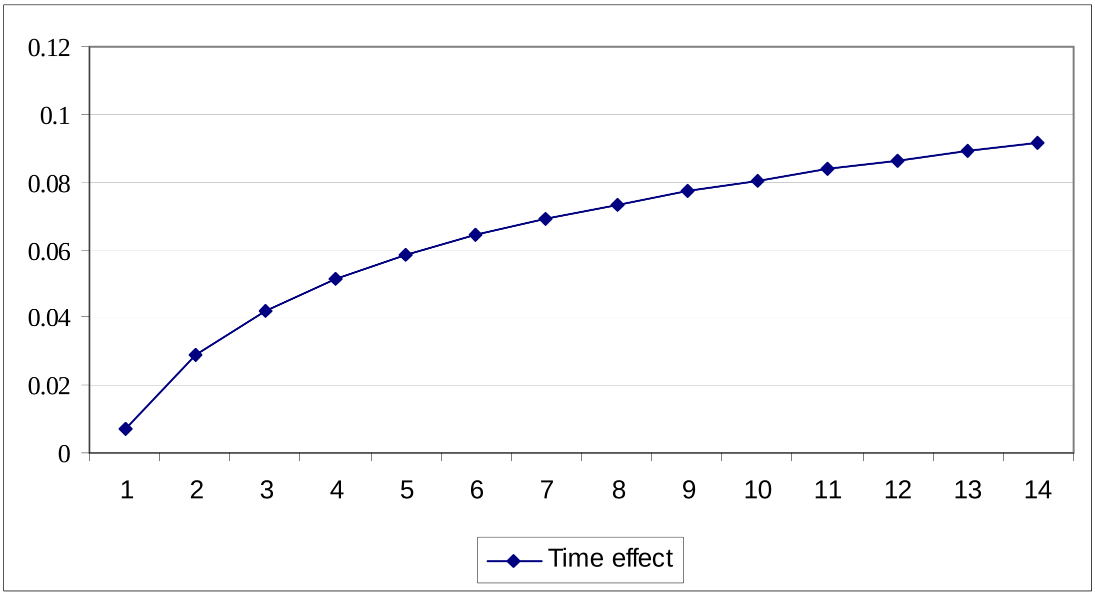
	Model with time-varying covariates	
	exponential decay	*hazard rate*
Distance to comparative advantage (log)	1.007	0.007
	(0.005)	(0.005)
Market diversification (log)	0.835***	-0.180***
	(0.003)	(0.004)
Product diversification (log)	0.906***	-0.099***
	(0.002)	(0.002)
Initial export (log)	0.959***	-0.042***
	(0.001)	(0.001)
Multispell	1.151***	0.140***
	(0.007)	(0.006)
Distance to comparative advantage	1.032*	0.032*
(log)*time (log)	(0.017)	(0.017)
Market diversification	0.914***	-0.090***
(log)*time (log)	(0.006)	(0.007)
Product diversification	0.947***	-0.055***
(log)*time (log)	(0.004)	(0.004)
Observations	464 251	464 251
Log pseudolikelihood	- 777 451	- 777 451

Notes: Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

The increasing impact of the distance from comparative advantage through time is shown in figure 2.3. The hazard rate, i.e. the likelihood of an export being terminated, of a product whose factor contents do not reflect the country's comparative advantage increases through time.

A negligible impact of comparative advantage on the hazard rate in the first few years may suggest that when countries select new exportable products, they do not take into consideration the underlying comparative advantage of the country. Also, for the initial period of exports, the exporting firms may try to stay in the market to absorb fixed costs, to acquire better knowledge of the market, or because of a presence of government support schemes. Once these supporting factors end, however, lack of competitiveness of the product arising from weak comparative advantage would make exports unsustainable.

Figure 2.3. Time-varying effect of distance to comparative advantage on export survival



We then check if the impact of comparative advantage on export survival is significant only for LDCs, or the same applies to other groups of developing countries. In order to assess this, we estimate the same Cox model for the member countries of the Association of Southeast Asian Nations (ASEAN) and those of the Southern Common Market (MERCOSUR). These countries are at a rather different level of development from LDCs, and their economic structure, export capacity and technological know-how may be dynamic enough to make distance to comparative advantage less critical.

Table 2.4 compares the results for ASEAN, MERCOSUR and LDCs. The signs and the magnitude of the impacts arising from market or product diversification upon the export hazard rate are similar across three groups, except the impact arising from comparative advantage. In the case of ASEAN, the coefficient of the distance to comparative advantage is negatively correlated with the hazard rate under the time-independent setup, then the coefficient loses its statistical significance once the interaction term with time is added.

Table 2.4. Results derived from Cox model with time interactions, ASEAN and MERCOSUR

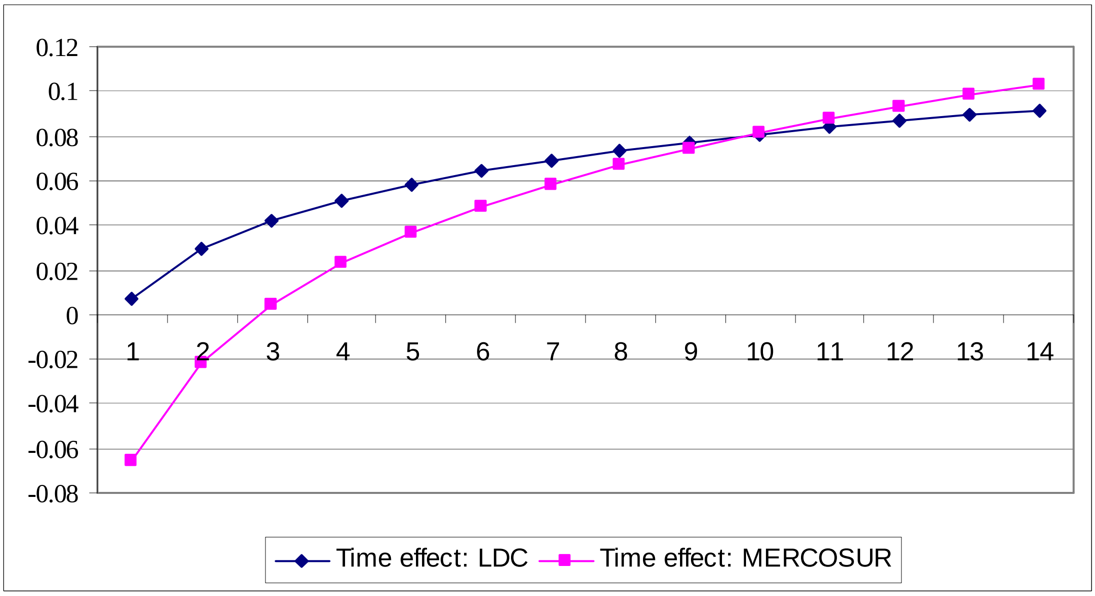
	Model with time-varying covariates		
	ASEAN	*MERCOSUR*	*LDCs*
Distance to comparative advantage (log)	0.983*	0.934***	1.007
	(0.01)	(0.014)	(0.005)
Market diversification (log)	0.878***	0.889***	0.835***
	(0.005)	(0.007)	(0.003)
Product diversification (log)	0.861***	0.986**	0.906***
	(0.004)	(0.006)	(0.002)
Initial export (log)	0.926***	0.925***	0.959***
	(0.001)	(0.001)	(0.001)
Multispell	1.795***	1.638***	1.151***
	-0.01	-0.009	(0.007)
Distance to comparative advantage (log) *time(log)	1.008	1.064***	1.032*
	(0.011)	(0.019)	(0.017)
Market diversification (log) *time(log)	0.805***	0.849***	0.914***
	(0.005)	(0.006)	(0.006)
Product diversification (log) *time(log)	0.949***	0.897***	0.947***
	(0.004)	(0.005)	(0.004)
Observations	2 882 511	1 151 673	464 251
Log pseudolikelihood	-2 963 905	-1 000 507	- 777 451

Notes: Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

As for MERCOSUR, the relationship between distance to comparative advantage and export hazard rate follows the same trend as that of LDCs. The time-varying effect of comparative advantage over the hazard rate through time of MERCOSUR and of LDCs is illustrated in figure 2.4. We find that the effect of the distance to comparative advantage on export survival in the first years of export is greater for LDCs than for MERCOSUR. Only after about 10 years, the distance to comparative advantage has a similar impact on export survival across the two groups of countries.

Further research is required to examine why the effect of comparative advantage on export survival is different across these country groups. Our educated guess at this stage is that the impact of comparative advantage in a traditional sense, i.e. human capital, physical capital and natural resources, is different across different product groups. There is a huge divergence in the export composition between the studied LDCs and ASEAN. For instance, the survival of exports of intermediary inputs (e.g. parts and components of electric devices), which represent a large share of ASEAN’s exports, may depend less on the relative abundance of human or physical capital and natural resources and more on the existence of export-facilitating institutions or infrastructure in their countries that enhance them being a part of a global supply chain.

Figure 2.4. Time-varying effect of distance to comparative advantage, least developed countries and MERCOSUR



3. Conclusions

Our study on LDCs' export spells finds that exported products that do not closely reflect the country's comparative advantage *at the time when the product is exported* are likely to survive only for a short duration in international market. Moreover, the impact of the country's comparative advantage on LDCs' export survival increases through time. Products outside the comparative advantage frontier are most likely to lack competitiveness in the international market. Thus sustaining export flows of such products becomes increasingly more difficult with time.

These findings lead to two implications to export diversification strategy of LDCs. First, in the short run, the government needs to pay close attention to whether a particular sector (or product) of export interest reflects the country's comparative advantage. Second, in order for LDCs to successfully diversify into non-traditional sectors that bear higher value added or more sophisticated factor contents in the long-run, their policy priority should be to constantly improve their comparative advantage. Comparative advantage of a country, particularly human capital, evolves dynamically through the years. Policies designed to increase both the quantity and the quality of human capital endowment (e.g. managerial skills and technological know-how), as well as to improve trade-facilitating institutions and infrastructure, would help increase the likelihood of successful export diversification into non-traditional product sectors.

Although suggestive, the analysis calls for further research. In particular, the effect of comparative advantage on export survival appears to differ across countries, and this call for a more thorough analysis. The importance of comparative advantage in explaining export survival may be related to differences in the export basket (i.e. the impact of comparative advantage upon export survival varies across product sectors) or, more generally, comparative advantage matters less and less as the overall economic capacity of a country increases (e.g. the availability of well-functioning trade-related institutions). A deeper investigation into these issues should help in the development of more tailored policy options for LDCs.

Appendix: Model specification

1. Kaplan–Meier analysis (nonparametric approach)

Export survival patterns can be characterized by the Kaplan–Meier estimator, which is a nonparametric estimate of the survivor function $s(t)$ or the probability of survival past time t. It is calculated as

$$\hat{S}(t) = \prod_{j|t_j \le t} (\frac{n_j - d_j}{n_j})$$

Where n_j is the number of spells at risk at t_j, and d_j is the number of completed spells of duration t_j. The Kaplan–Meier survival estimator gives the estimated probability of completing a spell at duration t_j, given that the spell has reached duration t_j.

2. Extended Cox Proportional Hazards Model (semiparametric approach)

To do so, we adopt a classic extended Cox Proportional Hazards Model. In this model, the distribution of durations can be characterized in terms of the hazard function. Let $P\left(t \le T \langle t + \Delta t \middle| T \ge t\right)$ be the probability of an export flow to be terminated in the interval $\left[(\mathrm{t}, \mathrm{t} + \Delta \mathrm{t})\right]$, given that it has lasted until time *t*. The hazard function is obtained by taking the limit of this probability for Δt.

$$h(t) = \lim_{\Delta t \to 0} P\left(t \le T \langle t + \Delta t \middle| T \ge t\right) \Big/ \Delta t = f(t) / S(t).$$

The hazard rate $h(t)$ is the probability that an export flow disappears at the duration *t*, given that they lasted until *t*. The independent variables can affect the distribution of the durations in several ways, depending on the specification used. The Cox Proportional Hazards Model is a semiparametric approach where no parametric form of the baseline function is specified, yet the effects of the independent variables are parameterized to alter the baseline survival function in a way that the independent variables multiplicatively shift the baseline hazard function.

The hazard function is as the following: $h(t \mid X_i) = h_0(t) \exp(X_i^{'} \beta)$

where the baseline hazard rate $h_0(t)$, which is not influenced by any independent variable, and each sample's hazard rate $h_i(t)$ that is a product of a function of the independent variables and the baseline hazard rate.

The advantage of this approach is that it helps us avoid potential misspecification of the hazard function.

The above function can be rewritten as: $\exp(X_i^{'} \beta) = \dfrac{h(t \mid X_i)}{h_0(t)}$

This hazard ratio gives the degree of effect created by one unit change in the independent variables on export survival. A hazard ratio that is smaller than one means that the independent variables, or covariates, have a reducing impact on the hazard rate, leading to a longer export survival.

One issue with using Cox regression is that it is based on the Proportional Hazard Assumption, whose implication is that the explanatory variables have the same effects at all points in time, meaning there is no interaction with time. There are, in general, two ways to deal with the violation of Proportional Hazard Assumption: (a) by stratifying or (b) by including the time interactions. We have used both methods.

First, the Cox model is extended to allow for non-proportional hazards for different products at the six-digit level of the Harmonized System using the method of stratification to account for different strata such that the stratified Cox Proportional hazards model for any country *i* and product *j* belonging to a stratum *k* is then given by the following model:

$$h(t_{ij} \mid X_{ij}) = h_k(t)\exp(X_{ij}^{'}\beta)$$

This extended model allows the baseline hazards to be arbitrary and unrelated for the different strata to control for unobserved differences across products. The large number of observations in our data set allows for a fine stratification. Unobserved differences across countries and years were dealt with by a fixed effects model.

Second, the Cox model is extended further to include time-interaction terms for time-dependent explanatory variables (covariates). A Cox model with time-varying covariates allows us to test whether the effect of covariates on the hazard rates changes through time. To incorporate time-varying covariates, the hazard rate is modelled as a step function, with different values of the covariates through intervals between $t = 0$ and $t = T$. T is the terminal value for the observation. A simplified Cox Extended Model with two covariates, one time-independent and one time-varying may be written:

$$h(t) = h_k(t)\exp(\beta_1 x_1 + \beta_2 x_2(t))$$

where the hazard rate at time *t* depends on the value of x_2.

Lastly, some exports may have several periods of continuous exporting that may be interrelated. For example, an exporter exports a certain product to a certain importer for a while, exit and re-exports again. As such consecutive exports may be interrelated, we use a dummy for multiple spells for an exporter-importer product. About 29 per cent of the spells of the study sample have multiple spells.

3. Estimating a product's distance from the exporting country's comparative advantage

The formula of the Euclidean distance of a product *k* to the comparative advantage of country *c* for any given year, omitting the time index, is the following:

$$D_{ck} = \sqrt{std(h_c - \hat{h}_k)^2 + std(k_c - \hat{k}_k)^2 + std(l_c - \hat{l}_k)^2}$$

where h_c, k_c, l_c are the country's human-capital, capital and land endowments and $\hat{h}_k, \hat{k}_k, \hat{l}_k$ are the revealed factor intensities of product *k*. We use D_{ck} as the measure of the closeness of each export product to the country's comparative advantage. We followed the methodology applied by Jaud, Kukenova and Strieborny (2009) to assess the role of comparative advantages in the survival of the exports of LDCs.

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