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Outsourcing Globally During the Product Life Cycle: A Theory and Some Evidence

Galina An
Department of Economics, University of Colorado at Boulder
Boulder, Colorado

Murat F. Iyigun
Department of Economics, University of Colorado at Boulder
Boulder, Colorado

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Center for Economic Analysis
Department of Economics

University of Colorado at Boulder
Boulder, Colorado 80309

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,SColo8itrp 80309

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1. Introduction

Economists have well established that learning-by-doing influences product proliferation, international trade, and economic growth.[1] They have also revealed that potential productivity gains from learning-by-doing decline as products or industries mature.[2] Together these findings suggest that embedding the learning-by-doing process into a product life cycle can be fruitful for better understanding the flows of foreign trade, in general, and the outsourcing activities of multinational enterprises, in particular. But, so far, theoretical and empirical work on how learning and the stages of the product life cycle jointly affect foreign trade and outsourcing has been lacking.

In this paper, we explore the relationship between learning and outsourcing during the product life cycle.[3] We develop a theoretical framework where products go through a standard life cycle and product quality is driven l por

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and n number of other goods produced by multinationals (MNEs). We assume that each good i; $i = 1; 2; ::: n$, is produced by one MNE which possesses monopoly power in the production of that good. Hence, each good and MNE are associated with one industry.

3.1. The consumer

The representative (worldwide) consumer maximizes the following utility function:

$$U = \sum_{=1} \frac{1}{®}(q\,y\,) \; + z; \qquad ® > 0; \tag{1}$$

subject to

$$\sum_{=1} p\,y\; + z = I \tag{2}$$

where z denotes the consumption of the numeraire good, p , y ; q respectively the price, the quantity, and the quality of good i, and I; $I > 0$, the income of the representative consumer.[6] This maximization problem yields the following inverse demand functions, $\forall$ i, with the non-transferable component of the production process.[7] Then MNE's profits if it produces in its home country, Π, are given by:[8]

$$\Pi = (p - C - M)y = q\ y\ - (C + M)y: \tag{4}$$

The MNE maximizes (4) by choosing the level of production y. The solution to this problem then yields:

$$y = \left(\frac{\alpha q}{C + M}\right)^{\frac{1}{1-}}, \tag{5}$$

which implies that the price for the good is given by a constant markup:

$$P = \frac{C + M}{\alpha} \tag{6}$$

According to (6), the price of the good is independent of its quality. Substituting the demand function given by (5) into the profit function of the MNE in (4), yields an expression of MNE's profits as a function of costs and quality. That is,

$$\Pi = (1 - \alpha)\left(\frac{\alpha q}{C + M}\right)^{\frac{}{1-}}. \tag{7}$$

3.3. Production Quality

The quality of the good, q, is given by the following:

$$q = A(H)e^{-1(\;)}; \tag{8}$$

[7] The marginal costs and can be respectively asociated with the assembly of products and the production of the intermediate inputs. In general, the assembly stage is more labor intensive, and the production of intermediates is more knowledge based. Therefore, it is relatively easier to contract out the assembly of products to developing countries, which in general have more (less) abundant unskilled (skilled) labor. Alternatively, and can be respectively assoM

where H denotes the human capital of ¯rm producing the good (which may or may not be the MNE), x, $x = 1; 2; :::X$, represents life cycle stage of the product, and Y denotes the cumulative production experience of the producer.[9] We assume that, $\forall$ H ≥ 0, $A^0 > 0$ and $A^{00} \leq 0$:

According to the speci¯cation in (8), product quality is bounded from above at A(H).[10] The term $e^{i1(\ )}$ in (8) captures the idea that cumulative production experience of the producer and the life cycle stage of the product determine the e®ective quality of the product. In particular, the production quality of a relatively new good (i.e. one which has a low x) is higher the more experience the producer has (i.e. the higher is Y). And, the quality of a good produced by a relatively inexperienced supplier (i.e. which has a low Y) is higher the more mature and standardized the product is (i.e. a product for which x is closer to X).

Let the subscript j be such that j = h for the MNE and j = f for the local supplier. By assumption, the MNE has more cumulative production experience than any local supplier so that $Y > Y$: Then, given that $\forall$ H ≥ 0, $A^0 > 0$, the MNE can produce goods that are of higher quality than a local supplier as long as its human capital, H, is at least as high as that of a local producer, H. Thus, if $H \geq H$, $q = A(H)e^{i1(\ )} > A(H)e^{i1(\ )} = q$.

3.4. Outsourcing

We now turn to the MNE's decision regarding the location of production. As we stated above, the MNE can either produce goods in their home country or outsource to a local supplier in a foreign country. An MNE might ¯nd it pro¯table to outsource the production of its good to a supplier in a less-developed or developing country, presumably because such a supplier has lower production costs. However, due to the fact that the cumulative production exa[illegible] than that of their counterparts in more advanced economies, MNE outsourcing might inherently entail a trade-off between quality and cost.

There are different mechanisms for an MNE to transfer the production of its good to the local supplier. These include host country-licencing, joint venture, subcontracting, and the establishment of a subsidiary. In most cases, the MNE and the local suppliers work together to maximize their joint profits. Thus, we assume that if the MNE outsources the production to a supplier in a foreign country, the MNE and the local producer maximize their joint surplus:

$$S = (z - v)\,(z - v)^{(1-\ )}, \qquad (9)$$

where γ; $0 < \gamma < 1$, parameterizes the Nash bargaining power of the MNE relative to the local supplier, and where $(z\ ; z\ ) \in \{G \cap [(z\ ; z\ ) | \ z \geq v \text{ and } z \geq v\ ]\}$; with G denoting the set of feasible payoffs, and $(v\ ; v\ )$ respectively the disagreement payoffs of the MNE and the local producer.

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$$z = T - cy$$

marginal production costs relative to the local supplier, the more willing it is to transfer to the local supplier the production of goods in the earlier stages of their PLCs.

Figures 1 and

4. Estim

sales revenue.[13] Based on the notion that R&D spending declines as the industry (or product) matures, we use this variable to proxy for the average life cycle stage of each industry. Then, using industry-wide exports as weights, we aggregate to determine the average life cycle stage of a country's exports. As an alternative but admittedly more subjective measure, we also use the United States Bureau of Economic Analysis (BEA) manufacturing industries code, and assign an index that ranges from 0 to 3 to each product code group. For product classes or industries where there is little or no manufacturing, we assign zero. For products with more manufacturing content, we assign 1 to older and highly standardized products, 3 to relatively new products, and of course, 2 to all those somewhere in between. Although in all results we show below we utilize the NSF R&D data as a proxy for the PLC index, the qualitative nature of what we present is robust to using the alternative PLC index we generated with the BEA code.

h .

0.234 1) Tj -411.75 -19.55 0 TD -0.06 Tc (t) Tj 4.5 0 TD 0.132 Tc (a) Tj 6 0 TD -0.06 T 0 TD -0.2
Tj 3.7j 6.75 0 TD (u)35 0 TD 0.) Tj 8.25 0 TD 0 TD -0.234 Tc (w) Tj 7.58. TD 4.5 015.23 (e) Tj .234
[illegible]
[illegible]

and subsequent cumulative per capita export shares.

Our empirical estimates of the effect of cumulative learning experience on export content, measured by the average PLC index of exports, are obtained by estimating the following equation with panel data:

$$PLCI_{it} = \mu_i + \lambda_t + \beta_1 CUMEXP_{i,t-1} + \beta_2 SCHOOL_{it} + \beta_3 X_{it} + \varepsilon_{it} \quad (19)$$

where $PLCI_{it}$ is an export-weighted PLC index of a country i at time t, μ_i is a country-specific effect, λ_t is a time specific effect, $CUMEXP$

between observations of both the PLC index, $PLCI$, and cumulative per capita exports, $CUMEXP$, so that we can observe significant changes in both our explanatory variable and dependent variable. Thus, we face a trade-off in constructing our data set: A larger number of years between observations allows us to examine more meaningful changes in the PLC index and the explanatory variables, but at the same time, it also reduces the number of time periods we include in our regression, lowering the efficiency of our fixed effects estimation. With these trade-offs in mind, we initially examine a fixed effects model with five-year sub-periods. Later, we also consider three other models with longer and shorter sub-periods, all of which yield similar empirical results.

Our panel nll og -yel

real GDP growth, GROWTH, gross foreign direct investment, FDI, and gross secondary school enrollment rates, SCHOOL, are from the (2001). Data on openness, OPEN, are from the Summers and Heston, Penn World Tables.

Tables 1.a and 1.b present summary statistics from our developing country sample and full sample. Both tables show th [illegible] sembly only. Put di®erently, assembly and re-exports are more prevalent for products that are in the earlier stages of their PLCs.

[Table 2.a about here.]

As stated earlier, our theory primarily focuses on MNEs' outsourcing production activity to low for which Cook's D > 1{and iteratively selects weights for the remaining observations to reduce the absolute va check the degree to which lagged values of the PLCI can explain the cross-country variations in PLCI over time. To this end, Tables 4.a and 4.b include the lagged values of the PLCI as an additional explanatory variable. As shown, while the lagged-PLCI explains a great deal of the variation in subsequent PLCI; the e®ect of the initial level of cumulative export experience, CUM [illegible] vol

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Table 1.a. Descriptive Statistics for Developing Countries

The Correlation Matrix

	Mean	S. D.	PLCI	CUMEXP	SCHOOL	IIT	OPEN	FDI	GDPCAP	GDPGR
PLCI	.996	.688	1.00	:::	:::	:::	:::	:::	...	...
CUMEXP	.020	.060	.577	1.00	:::	:::	:::	:::	...	...
SCHOOL	38.73	25.47	.389	.316	1.00	:::	:::	...	...	...
IIT	30.11	18.44	.496	.447	.511	1.00	:::	...	...	...
OPEN	64.65	44.69	.462	.741	.290	.324	1.00	...	...	...
FDI	3.81E+7	..								

.TLi 3 0 TD 0.132 Tc (0) Ti 6 0 TD (0) Ti ET 561 385.5 0.24 14.25 t 0.24 1 Tc (0) Ti 6 0 TDre S 111.75 384.75 612.75 0.24 re S 111 370.5 0.

Table 2.a. Fixed E®ects Estimation{ Developing Countries (Lag One)

Dependent Variable: PLC index

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			Robust Errors			Robust Regressions		
EXPRATIO$_{t ¡ 1}$	9.267¤ (.800)	6.731¤ (1.011)	3.344¤ (1.425)	9.267¤ (1.573)	6.731¤ (1.390)	3.344¤ (1.550)	7.568¤ (.274)	7.053¤ (.405)	4.916¤ (.574)
SCHOOL$_t$	.006¤ (.003)	.003 (.003)	.002 (.003)	.006¤ (.003)	.003 (.002)	.002 (.002)	.001 (.001)	.0001 (.001)	.0001 (.001)
IIT$_t$	...	.013¤ (.002)	.012¤ (.002)	...	.013¤ (.003)	.012¤ (.002)	...	.006¤ (.001)	.005¤ (.001)
OPEN$_t$	...	.003¤ (.001)	.003¤ (.001)	...	.003 (.002)	.003 (.002)	...	-.00004 (.0005)	-.000004 (.0005)
FDI$_t$	...	.474¤ (.204)	.355¤¤ (.204)	...	.474¤ (.221)	.355¤¤ (.204)	...	.129 (.082)	.103 (.082)
GDPCAP$_t$	...	...	.102¤ (.031)	...	...	.102¤ (.031)	...	...	.062¤ (.012)
GDPGR$_t$	...	...	-.006 (.005)	...	...	-.006 (.005)	...	...	.001 (.002)
R ¡ squared	.84	.88	.89	.88	.92	.92	...	...	...
No: of obs:	384	369	369	384	369	369	384	369	369

Note: Country-speci¯c and time-speci¯c ¯xed e®ects estimate. Heteroskedasticity-corrected standard errors are in parenthesis. *, ** respectively denote signi¯cance at the 5 percent and 10 percent levels.

Table 2.b. Fixed Effects Estimation–All Countries (LagOne)

Dependent Variable: PLC index

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			Robust Errors			Robust Regressions		
$EXPRATIO_{t-1}$	5.793* (.489)	5.366* (.430)	4.695* (.479)	5.793* (.857)	5.366* (.800)	4.695* (.790)	4.382* (.187)	4.348* (.185)	3.540* (.208)
$SCHOOL_t$	.004* (.002)	.003 (.002)	.001 (.002)	.004* (.002)	.003 (.002)	.001 (.002)	.004* (.001)	.002* (.001)	.001 (.001)
IIT_t	...	.013* (.002)	.013* (.002)	...	.013* (.003)	.013* (.002)	...	.005* (.001)	.005* (.001)
$OPEN_t$	...	.002** (.001)	.003* (.001)	...	.002 (.002)	.003 (.002)	...	-.00002 (.0005)	-.00004 (.0005)
FDI_t	...	.059* (.017)	.030 (.019)	...	.059* (.018)	.030** (.017)	...	.055* (.007)	.035* (.008)
$GDPCAP_t$	...	...	.035* (.011)	...	...	.035* (.012)	...	...	.031* (.005)
$GDPGR_t$	...	...	-.005 (.005)	...	...	-.005 (.005)	...	...	.001 (.002)
R − squared	.88	.91	.91	.91	.93	.94	...	...	...
No. of obs.	485	463	463	485	463	463	485	463	463

Note: Country-specific and time-specific fixed effects estimate. Heteroskedasticity-corrected standard errors are in parenthesis. *, ** respectively denote significance at the 5 percent and 10 percent levels.

Table 3.a. Fixed E®ects Estimation{Developing Countries (Lag Two)

Dependent Variable: PLC index

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			Robust Errors			Robust Regressions		
$EXPRATIO_{t-2}$	10.987¤	9.348¤	5.700¤	10.987¤	9.348¤	5.700¤	9.740¤	8.712¤	3.714¤
	(1.120)	(1.408)	(1.940)	(1.859)	(1.432)	(1.779)	(.375)	(.525)	(.737)
$SCHOOL_t$	.008¤	.003	.002	.008¤	.003	.002¤	.002	.001	.001
	(.004)	(.003)	(.003)	(.004)	(.004)	(.003)	(.001)	(.001)	(.001)
IIT_t	...	.014¤	.013¤	...	.014¤	.013¤	...	.004¤	.004¤
		(.003)	(.003)		(.003)	(.003)		(.001)	(.001)
$OPEN_t$	...	.005¤	.006¤	...	.005¤¤	.006¤	...	.0003	.0006
		(.001)	(.001)		(.003)	(.003)		(.0005)	(.0005)
FDI_t									

t

Table 3.b. Fixed E®ects

Table 4.a. Fixed E®ects Estimation{Dev. Countries (Controlling For Lagged

Table 4.b. Fixed Effects Estimation—All Countries (Controlling For Lagged PLC)

Dependent Variable: PLC index

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			Robust Errors			Robust Regressions		
$EXPRATIO_{t-1}$	2.308*	2.608*	2.427*	2.308*	2.608*	2.427*	2.139*	2.306*	2.279*
	(.426)	(.395)	(.420)	(.578)	(.592)	(.573)	(.190)	(.191)	(.206)
PLC_{t-1}	.692*	.592*	.582*	.692*	.592*	.582*	.669*	.633*	.633*
	(.042)	(.042)	(.043)	(.091)	(.086)	(.085)	(.019)	(.020)	(.021)
$SCHOOL_t$	.003*	.002	.002	.003*	.002**	.002	.002*	.001*	.0014**
	(.001)	(.001)	(.001)	(.001)					

Table 5.a. Reverse Causality–Developing Countries

Dependent Variable: Cumulative Per Capita Exports

	(1)	(2)	(3)	(4)	(5)	(6)
PLC_{t-1}	.001 (.003)	.001 (.002)	.0002 (.0002)	-.003* (.001)	-.003** (.002)	-.0001 (.0001)
$EXPRATIO_{t-1}$	...	...	...	.917* (.033)	.917* (.074)	.827* (.003)
$SCHOOL_t$	-.221* (.110)	-.221* (.105)	-.012 (.009)	.067 (.057)	.067 (.043)	.009** (.006)
IIT_t	-.170 (.105)	-.170** (.091)	.021* (.009)	.061 (.054)	.061 (.040)	.014* (.005)
$OPEN_t$	.076 (.053)	.076 (.078)	.011* (.005)	.057* (.027)	.057 (.041)	.018* (.002)
FDI_t	.039* (.009)	.039* (.018)	-.002* (.001)	-.006 (.005)	-.006 (.010)	-.0005 (.0004)
$GDPCAP_t$	.013* (.001)	.013* (.004)	.005* (.0001)	-.0006 (.0007)	-.0006 (.0007)	-.001* (.0001)
$GDPGR_t$	-.087 (.231)	-.087 (.160)	-.035** (.020)	-.086 (.117)	-.086 (.078)	.003 (.010)
R - squared	.97	.98	...	.99	.99	...
No. of obs.	373	373	373	369	369	369

Note: Country-specific and time-specific fixed effects estimate. *, ** respectively denote significance at the 5 percent and 10 percent levels.

Table 5.b. Reverse Causality{All Countries

Dependent Variable: Cumulative Per Capita Exports

	(1)	(2)	(3)	(4)	(5)	(6)
PLC_{t-1}	.033*	.033*	.002*	-.0002	-.0002	.0001
	(.005)	(.011)	(.0004)	(.003)	(.003)	

30TD (0) Tj 6 0 TD (3) Tj 6 0 TD -0.06 Tc ()) Tj ET 482.25 428.25 0.65Tj 4.5 0Tc (-) Tj 3