Export Dynamics : Evidence from Global Mobile Phone Industry *

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February 28, 2025

Abstract

This paper studies firms' export dynamics using evidence from the global cellphone industry. Exporters tend to enter foreign markets that are geographically close or culturally similar to their previous export destinations. Most structural work of international trade ignored firms' sequential export decisions across countries when estimating the entry costs or failed to build a framework in which firms' export-dynamic actions can be tractable and obtain an accurate estimation of entry costs. I build a dynamic model in which firms first sequentially choose regions for penetration and then spread over the countries in the regions. I estimate the firms' region and country-level entry sunk costs to start a business and country-specific fixed costs to maintain operation. I find that entering a new region with similar consumer characteristics with the previous export regions could reduce the entry costs by 58%, and adding countries after penetrating a region would incur much lower entry costs. The trade protection in large countries, such as the G7 group, would also reduce the entry margins of importers and trade value in the surrounding smaller European countries. Conditional on the same productivity level, the geographical location of a firm's headquarter could determine as much as 70% of the variation of global expansion and sales.

Keywords: entry costs, export dynamics, market complementarity

*I am indebted to Jonathan Eaton, Mark Roberts, and Stephen Yeaple for their continuous advice and support. I thank Treb Allen, Jason Blevins, Jingting Fan, Paul Grieco, Vijay Krishna, Charles Murry, Peter Newberry, Fernando Parro, Stephen Redding, Karl Schurter, and James Tybout for insightful conversation and comments. I am grateful to seminar participants at the Trade/Development Reading Group and Industrial Organization Brown Bag at Penn State for useful feedback. All errors are of my own.

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1 Introduction

Most new products are unavailable to most customers. For customers in a country to obtain access to a product, its producer must incur a variety of costs. Literature attempts to estimate these entry costs (Das, Roberts, and Tybout, 2007; Arkolakis 2010; Dickstein and Morales, 2018; Morales, Sheu, and Zahler, 2019).

Nevertheless, this literature pays little attention to firms' entry dynamics across countries. The data indicate that firms tend to make sequential entry decisions across countries and enter foreign markets that are geographically close or are culturally similar to their previous export destinations. These sequential choices might be the results of signals along the way, or they might reflect firms having faced organizational constraints. It stands to reason that there may be dependence across locations that can be heterogeneous across firms and locations. As an example, a firm's entry costs to Belgium can be very different if the same firm is also selling in France. Thus, in an international market characterized by such possible dependencies, ignoring exporters' sequential entry strategies in their expansion paths would lead to inaccurately estimated entry costs, false predictions of firms' penetration status across countries, and biased evaluations of trade liberalization gains.

Sequential entry matters; consider that a decision to enter country A could be motivated by the potential to improve the chance of success upon future entry into country B. In this way, firms could, essentially, treat markets as complements in their sequential export entry plans - but this also means, in turn, that a given country's import policy could influence other countries' market competition. In 2015, for example, five Chinese mobile phone firms (Huawei, ZTE, Lenovo, Meizu, and One Plus) operated in Belgium, while three of those five also operated in Canada (Huawei, ZTE, and One Plus). Canada is four times larger than Belgium, with many more Chinese immigrants, but fewer Chinese mobile phone firms. A reason could be that the mobile phone markets in France and Germany were very open to Chinese brands, which also encouraged them to spread their business to surrounding countries like Belgium and Austria, while the U.S. market's difficulty discouraged the Chinese firms from entering Canada.

Nonetheless, despite the complexities inherent in such decisions, previous studies on the impact of one country's trade policy externality on other countries have tended to focus

more on market rivalry, such as how China's accession to the WTO reduces other countries' employment. One potential trade-policy externality that has been ignored thus far is how a country that is more open to trade might encourage more firms (and varieties) to flow into itself, and how this, in turn, might impact firms' expansion decisions regarding such a country's geographic and cultural neighbors.

Although these export entry dynamics and market complementarity problems are intuitive, they are challenging to accommodate in a structural econometric model. A dynamic behavior model that can track firms' entry sequences in different locations can better illuminate how the attendant profits and costs might push firms to make their interrelated export decisions.

Thus, in this paper, using global cellphone industry data, I develop a methodology to estimate entry costs while taking firms' sequential entry decisions into account. I build a dynamic framework to track firms' export entry dynamics and their sales across countries, and I conduct counterfactual policy analyses to answer several key questions. First, what are the costs associated with exporters' penetration of a country? Relatedly, how much can firms' current penetration status reduce the entry cost of a market that is geographically close or culturally similar to the country or countries where the firm already has a presence? Second, how do large countries' regulations potentially affect the market competition in their small and surrounding neighbors? Third, how can geography determine firms' expansion paths? Finally, how much can we gain from more advanced infrastructure and fewer trade costs under the process of globalization?

Studying exporters' entry sequences across countries is challenging. Consider a firm attempting to enter 40 countries one by one; there are at least 40! different entry sequence combinations possible in such a case. As such, it is computationally infeasible to list all the possible sequences and find the optimal one. I show that most firms' strategy for entering foreign markets involves penetrating one key country in a region and then using that country as a base from which to spread into other countries in the same region. Therefore, I partition the world into regions in which countries are geographically close, culturally similar, and share high entry correlations. I treat firms' entry strategies as following two margins: a region-level entry action and a within region country-level entry action. Intuitively, the identification comes from variation in a given firm's region- and country-level entry decisions.

As the state space of my dynamic optimization is limited, and my cost estimates are point-identified, I can calculate the probability of firms' following each possible entry sequence, predict firms' dynamic export entry decisions, and conduct the counterfactual policy analysis I articulated before.

I disentangle the entry costs that a firm incurs by accounting for three levels: the region-level entry cost, the country-level entry cost, and the country-specific fixed cost for maintaining sales. My estimation indicates that entering a new region whose consumer characteristics are similar to previous export regions vastly reduces the region-level entry costs; in fact, in the extreme case, the regional entry cost can be as much as 81% smaller if a firm has already penetrated a very similar region. Moreover, the entry sunk cost for a new destination country falls drastically after any other country in the same region has been entered, and the fixed cost for maintaining regular operations is much smaller than the other two sorts of entry costs.

There is much controversy about 5G technology and equipment in G7 countries. Moreover, the reduced demand and higher entry barrier in G7 countries could also discourage firms' entry and sales decisions in their geographical neighbors and culturally similar countries. Taking the 5G example, I conduct an analogical counterfactual analysis. Suppose that, when smartphone products started to boom in 2007, the debates surrounding data privacy and national security in the G7 countries had reduced their consumers' demand by 30% and that governments had scrutinized and delayed the licensing process for new products by doubling the processing time. Given these conditions, I examine how the entry margins and market competition in other countries might have changed. The results show that other western European countries' entry margins could have fallen by around 10%, and their import value could have decreased by around 3%.

This paper also contributes to the literature on economic geography. The location of a firm's headquarters contributes greatly to its success, as location determines the distance between a headquarters and significant sourcing locations, or between a headquarters and the firm's destination markets (not to mention the related impact of home market size). Moreover, geography plays a vital role in the market exposure of exporters in its expansion fictional and affects firms' total revenue at different periods. To examine these influences, I create a firm established in 2010 and having the same productivity level as Huawei. Then I

assign different headquarter locations to the same firm and simulate its export expansion over a period of 5 years from its founding, comparing the results for each location. Surprisingly, conditional on identical productivity, the worst headquarter location's global revenue is just 30% of the best location's global revenue.

Gains from global infrastructure projects are often the focus of international economists. Under the Belt and Road Initiative, the process of globalization has advanced substantially as thousands of railroad improvements and port construction projects have been completed to deeper connect the west and the east, and the practical "distance" between any given pair of countries shortens. Therefore, with my model primitives, I propose a world with more advanced infrastructure, which can shorten the world's distance by half, reduce delivery cost, and greatly enhance market competition in each country. The results indicate that consumer surplus can increase by 1.3% to 3.87% in the mobile phone market in such a closer world. Compared to a static model, my dynamic model would predict a smaller increase in the number of entrants and consumer surplus in the short run but a larger increase in the number of entrants and consumer surplus in the long run.

The remainder of this paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the data. Section 4 shows the motivating evidence. Sections 5 and 6 describe the model and empirical implementation. Section 7 introduces the counterfactual analysis, and Section 8 concludes.

2 Literature Review

This paper contributes to the literature on the dynamics of export and expansion at the firm level. To my knowledge, Morales, Sheu, and Zahler (2019) is the paper most influential and relevant to the current study; their work considers firms' forward-looking entry strategies when estimating entry costs and finds that firms can significantly reduce export entry costs by entering countries that are similar to their previous export destinations. The authors describe this effect as "extended gravity." Furthermore, to alleviate the computational burden and transfer the dynamic optimization to a static comparison, the authors apply one-period deviation and construct moment inequalities to identify the costs. Their identification strategy assumes that any entry decision to enter another country will not be affected by the

one-period deviation. In fact, the deviation would change the entry costs of other countries in the future, and their identification tends to underestimate the bounds of the extended gravity effect without consideration of the change in other periods [1]. Another problem with their approach is the space of the firms' choice set of entry sequences is still huge, and with partially-identified cost estimates, it is hard for their model to track firms' dynamic entry sequences. As a result, the potential policy extrapolations are very limited.

Except for this extended gravity paper, Holmes (2011) estimates the determinants of Walmart stores' expansion within the United States. Both Holmes's' paper and Morales et al. (2019) use moment inequalities to conduct their estimation, but the counterfactual analysis is relatively limited. Chaney (2014), meanwhile, relates the dynamics of French firms' exports to a novel theory of informational frictions in trade but pays little attention to costs, profits, and trade gains. By contrast, my approach makes assumptions about firms' entry behavior without losing the fit to the data, relying on a dynamic model that is point-identified and enables us to track the entry sequences of exporters in order to conduct counterfactual analysis. While the firms' dynamic export strategy in my own model is similar to the mechanism in Chaney's (2014), the current paper identifies the costs and profits to deduce the probability of entry in addition to his mechanism.

My paper also supplements the existing literature on identifying export entry costs. Aside from the original static entry costs, Das, Roberts, and Tybout (2007) develop a dynamic structural model of export supply that embodies market entry costs for new exporters. Arkolakis (2010) develops a theory of market-penetration cost with a new consumer margin to accommodate many small exporters in each exporting market. Dickstein and Morales (2018) evaluate how the information potential that exporters possess influences their entry decisions. Adding to all of these, my paper identifies the different entry costs that firms incur in their sequential export entry strategy.

The current paper, furthermore, relates to the literature on the computation of dynamic entry models. I apply the conditional choice probability method in order to model firms' entry; this method is an application of Arcidiacono, Bayer, Blevins, and Ellickson's (2016) work that delivers a formulation of a dynamic game in continuous time. The conditional choice probability method we apply here originates from the seminal work of Hotz and Miller

[1] See Appendix 9.1.

(1993) and is consistent with a wide range of dynamic discrete choice problems (Aguirregabiria and Mira, 2007; Bajari, Benkard, and Levin, 2007; Pakes, Ostrovsky and Berry, 2007; Pesendorfer and Schmidt-Dengler, 2008; Arcidiacono and Miller, 2011). To back out the sunk cost to each country, I also apply the dynamic estimation method presented in Das, Roberts, and Tybout (2007) and in Aw, Roberts, and Xu (2011).

For my own analysis, I use data from the global cellphone industry to analyze the policy implications for this and other worldwide industries, consistent with similar work of Head and Mayer (2019) and Cosar, Grieco, Li, and Tintelnot (2018)[2].

3 Data

I use data on the global mobile phone industry. The majority of firm-level data that I use come from the Worldwide Quarterly Mobile Phone Tracker, a market research endeavor by the International Data Corporation (hereafter "IDC"). This dataset is built upon the IDC's network of country-level mobile phone tracking services, and its bottom-up methodology delivers an accurate view of the mobile phone market from those closest to it. Their tracker covers all cellphones sold in more than 70 countries/regions. To supplement the IDC's sales data, this paper also uses the product, brand, and sales information on smartphone models collected by BDA China Market Research, to identify further information on firms and products.

This paper includes quarterly data for 40 major countries, from the first quarter of 2007 to the second quarter of 2016. Table 1 shows the countries in my dataset. The 40 countries that I use account for 90% of total GDP across the world, according to the 2016 World Bank statistics, and suffice to capture the majority trade flow, globally.

The most important variable is each cellphone firm's sales information, per country, per quarter. Specifically, each firm's sales value for each country/quarter is the sum of all the products it sold in that country and quarter. Each product's sales value, in turn, is the numerical product of sales quantity and average selling price for that product. Meanwhile,

[2]Head and Mayer (2019) estimate a model of international trade and foreign production using sourcing data from the automotive industry, conducted much analysis of the effect of trade union and trade regulation on global production. Cosar, Grieco, Li, and Tintelnot (2018) use the same automotive data, combines a demand-side from Berry, Levinsohn, and Pakes (1995) with the multinational production model of Tintelnot (2017) to study the home market advantage. Consistency with them, I also use worldwide data of a specific industry to capture the firm entry and sales behaviors and give policy directions.

Table 1: The 40 Countries/Geos in the Data

America	Asia & Pacific	Eastern Europe	Western Europe
Argentina	Australia	Russia	Austria
Brazil	Hong Kong	Ukraine	Belgium
Canada	India		Denmark
Chile	Indonesia		Finland
Colombia	Japan		France
Mexico	Malaysia		Germany
USA	New Zealand		Ireland
Venezuela	Pakistan		Italy
	Philippines		Netherlands
	China, Mainland		Norway
	Singapore		Portugal
	South Korea		Spain
	Taiwan		Swenden
	Thailand		Switzerland
			United Kingdom

The 40 countries/geos above take 90% of the world's GDP in 2016.

sales quantity is a measure of the number of new mobile phones that a firm shipped to all distribution channels or directly to end-users; average selling price is the average end-user price paid for a typically configured mobile phone. Average selling price includes all freight, insurance, and other shipping and handling fees, such as taxes and tariffs included in channel pricing; point-of-sale taxes (e.g., VAT or sales tax) are generally excluded. Additional subsidies that mobile operators might offer are also not factored into this price. Because the average selling price estimates the final price by the average end-users, it includes the implicit channel markup embedded in the final price.

With each firm's sales information in each country/quarter, I can deduce when each firm first started selling in each country. If none of a given firms' products was recorded in the sales information for a specific country/quarter, then I conclude that the firm did not enter the market during that period. I use such a method to judge the existence of each firm's economic activity in each country/quarter. I also collect and double-check the information on each cellphone firms' headquarters, production, entry, and sales by searching its official website, reading-related news, and checking product pictures online.

With such a methodology for collecting the sales and entry information, I then observe each firm's quarterly sales in each country. Table 2 shows a brief summary of the entry and sales information in the data. If in a given quarter, one firm's products are available in a

specific country, this counts as an entry. # of firms is the total number of active mobile phone firms in the world each year. # of entries represents the measure of available firm-country-quarter observations each year. The entry information shows that the global mobile phone market was an emerging industry after 2007 as the number of active firms grows almost every year. The sales information lists the sales range of each firm-country-quarter observation in each year. One firm earns a revenue a of USD 16 billion in a country-quarter (the iPhone's sales in the USA, the fourth quarter of 2014), while there are small firms in the data that only sell at most USD 10 thousand in a country-quarter. All in all, however, the mean quarterly sales per firm show that the per-firm revenue tends to be large in this industry.

Table 2: Summary Statistics of the Data

Quarterly Basis	Entry Information		Sales Information		
Year	# of firms	# of entries	Mean	Max	Min
2007	70	2213	84.23	4,031	0.01
2008	86	2335	85.07	2,958	0.01
2009	102	2237	80.71	2,961	0.01
2010	108	2259	96.31	3,561	0.01
2011	120	2375	109.43	10,853	0.01
2012	141	2500	117.25	11,075	0.01
2013	170	2582	126.81	10,814	0.01
2014	199	3161	112.28	16,391	0.01
2015	228	3685	100.29	14,873	0.01
2016	221	1937	84.18	9,538	0.01
Total	321	25,284			

Notes: I have only two quarters' data in the year 2016, and the scale of sales is millions of US Dollars.

As a supplement to the mobile phone industry's data, the trade data, capturing the sourcing from the production country to the destination country, comes from the UN Comtrade import data for industry 851712 (i.e., telephones to be used in the cellular network). Each country's wage, GDP, and income inequality data, meanwhile, come from the World Bank and the IMF, and the tariff and regional trade agreement data come from the WTO database.

4 Motivation Evidence

I now turn to describing the entry dynamics and sales patterns that bear on the specific features of the model estimated here. I will start with an expansion example involving a specific firm, Xiaomi.

4.1 Export Dynamics

4.1.1 Xiaomi's Expansion Path Example

Xiaomi is a cellphone brand from mainland China, and Figure 1 shows its expansion path. It was established in the last quarter of 2011, and the figures show how Xiaomi spread its business in the first four years of its existence.

As seen in the figures, Xiaomi first expanded to Hong Kong and Taiwan in the second quarter of 2013. Then, in the first quarter of 2014, it started to spread into countries in Southeast Asia and Eastern Europe. Two quarters later, it entered India and Western European countries as well. By the end of the period represented in the figures, Xiaomi had entered the USA, Russia, and almost all of the central Western European countries.

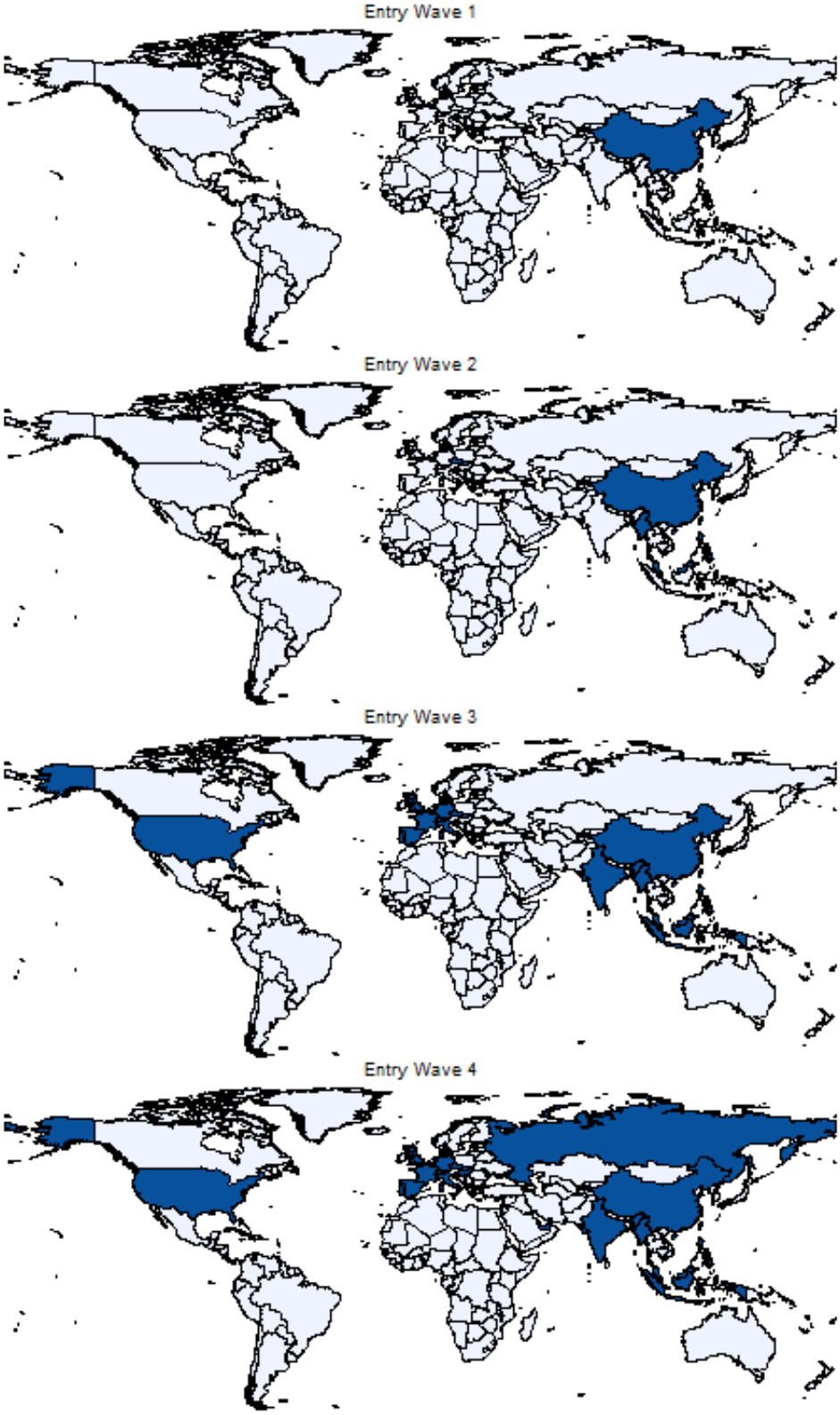
Granted, the world is not perfectly connected. It does consist of regions in which countries are geographically close and share a similar culture and set of consumer preferences. Xiaomi's entry strategy can be seen as one of penetrating one key country in a given region initially, and then using that country as a base from which to spread into other countries in the same region. The idea of such a spread mechanism is similar to what Chaney (2014) proposed. Each location has a probability of being penetrated by the exporter, and then, the exporter uses the penetrated location as a base to enter surrounding locations.

In the next section, I treat the whole world as a set of regions and propose a standard for partitioning the countries into different ones. Then, I check whether countries within the same region share a much stronger entry correlation with each other than with countries of other regions; this test is used to support the partition standards. Based on this partition, then, I capture the pattern of firms' entry dynamics along two margins:

1. within-region penetration: how firms spread over countries in the same region

2. across-region penetration: how firms enter regions sequentially

Figure 1: Xiaomi's Expansion Path from 2011 to 2015



Next, I introduce the standard by which I partition countries into regions.

4.1.2 Entry Correlation and Partition the World

I take 10 European countries – Belgium, Switzerland, Denmark, France, Germany, Italy, Spain, the United Kingdom, Russia, and Ukraine as an example, and Table 3 shows which countries have the highest entry correlations with them[3]. The column labeled "Country" shows the ten objective countries I study here. # indicates the total number of foreign entrants that have ever entered each objective country during my data observation period. If a foreign firm penetrates Country A and Country B within 2 years of each other, I define this as a correlated entrance between Country A and Country B. Next, I calculate the fraction of correlated entrants to each country among all the entrants that have ever penetrated each country. Then I rank the countries with the highest fraction of correlated entrants with the objective countries and show the top 5 countries for each objective country.

In the first row, the top 5 countries that correlate most highly with Belgium with respect to entrance are Germany, Italy, Switzerland, Spain, and France. 81% of the firms that have penetrated Belgium also penetrated Germany, Italy, and Switzerland within two years when they penetrated Belgium. Then, 79% of the firms to penetrate Belgium also penetrated France and Spain within two years of when they penetrated Belgium. If no more than 60% of each objective country's entrants penetrated another country within two years, I would not list the country as being entry-correlated with that country.

Table 3: Entry Correlation of Countries

Country	#	Relation 1	OE %	Relation 2	OE %	Relation 3	OE %	Relation 4	OE %	Relation 5	OE %
Belgium	58	Germany	81	Italy	81	Switzerland	81	Spain	79	France	79
Switzerland	55	Belgium	85	Italy	84	Germany	82	France	82	Spain	80
Germany	67	UK	78	France	78	Spain	73	Italy	73	Belgium	70
Denmark	47	Switzerland	87	Belgium	83	France	83	Italy	81	Sweden	79
Spain	65	Italy	78	UK	78	France	77	Germany	75	Belgium	71
France	70	Germany	74	UK	73	Spain	71	Italy	71	Belgium	66
UK	70	Germany	74	Spain	73	France	73	Italy	67	Belgium	60
Italy	63	Spain	81	France	79	Germany	78	Belgium	75	UK	75
Russia	55	Ukraine	78								
Ukraine	54	Russia	80	Italy	61						

OE is short for overlapping entrants and measure in percentile. Its number indicates the percentage of the total firms having penetrated each country within two years of the date it penetrated each objective country.

From Table 3, Russia and Ukraine are geographically connected, and they are also each

[3]See Table 20 in the Appendix for the full entry information.

other's most entry-correlated country. I group Russia and Ukraine into the same Eastern Europe region. France, Germany, the UK, Spain, and Italy are geographically close as well, and they are also each others' most entry-correlated countries; I put these countries into the same region, Western Europe. Furthermore, when I check the countries that are most entry-correlated with Belgium and Switzerland, those five large countries, along with Belgium and Switzerland themselves, are still Belgium and Switzerland's most entry-correlated countries. It is strong evidence that outside firms will first penetrate those five large firms and then spread to smaller surrounding countries, such as Switzerland and Belgium[4]. As a result, I also place Belgium and Switzerland in the same group as Germany, France, Italy, Spain, and the United Kingdom. Following the same logic, Denmark can also be treated as entrants' further spreading countries after penetrating France, Germany, the United Kingdom, Spain, Italy, Belgium, and Switzerland. Thus, I put Denmark in the same region.

When I partition the countries into different regions, I check whether the countries are geographically connected and whether they are each other's most entry-correlated countries. Based on the entry correlation standard shown in Table 3 and the countries' geographical information, I partition the 40 countries in my data into 12 regions. Table 4 shows these 12 regions and their components.

I further use a reduced-form specification to consolidate the effectiveness of the partition method:

$$Pr(Entry_{ijt} = 1) = \beta_1 Entry_{ijt-1} + \beta_2 Region_{ijt-1} + \beta_x X_{ijt} + F_i + F_j + T_t + \epsilon_{ijt}$$

$Entry_{ijt}$ is the dummy indicator that firm i's products are available in country j in quarter t, and $Region_{ijt-1}$ is the dummy indicator that firm i's products are available in any country of the region to which country j belongs in quarter $t-1$. X_{ijt} includes the log of distance, the home country dummy, and whether the same language is used in both firm i's headquarters and in country j at quarter t, as the control variables. F_i, F_j, and T_t are the firm fixed effect, country fixed effect, and time fixed effect, respectively.

I estimate the reduced-form equation by OLS, Probit, and Logit, respectively, and report the regression results in Table 5. β_2 is the coefficient in which I am interested. All 6 columns

[4]See Appendix Section 9.3.

Table 4: Partition the 40 Countries/Geos into Regions

China	Japan & Korea	Hong Kong & Taiwan	India	Pakistan	Pacific
China, Mainland	Japan	Hong Kong	India	Pakistan	Australia
	South Korea	Taiwan			New Zealand

North America	Latin America 1	Latin America 2	Southeast Asia	Eastern Europe	Western Europe
Canada	Argentina	Chile	Indonesia	Russia	France
USA	Brazil	Colombia	Malaysia	Ukraine	Germany
	Mexico	Venezuela	Philippines		Italy
			Singapore		Spain
			Thailand		United Kingdom
					Austria
					Belgium
					Ireland
					Netherlands
					Portugal
					Switzerland
					Denmark
					Finland
					Norway
					Sweden

report the significant increase in probability of entry once any other country in the region is penetrated. This table offers robust evidence to support my partition standards, and firms export to the countries of the same region together.

4.2 Patterns in Entry Dynamics

Based on the partition method just detailed, I now describe two facts that bear on the specific features of the dynamic entry model that I estimate. The first relates to firms' entry actions with respect to countries, conditional on the penetration of a given region: in other words, the country-level penetration within each region. The second relates to firms' entry dynamics across regions that I add to the model: the region-level penetration.

4.2.1 Penetrations Within a Region

Table 6 shows the firms' entry probability with respect to each country in my data. # of entrants shows the number of firms having ever penetrated each specific country during the data observation period. The unconditional entry probability represents the proportion of the total firms (321) to penetrate each specific country during the whole data period. Finally, the entry probability for a given country conditional on the penetration of the region - i.e., conditional entry probability - shows the probability of penetration for each specific country

Table 5: Entry Correlation within the Region

	$Entry_t$					
VARIABLES	OLS	Probit	Logit	OLS	Probit	Logit
	(1)	(2)	(3)	(4)	(5)	(6)
$Entry_{t-1}$	0.877***	3.066***	5.404***	0.800***	2.532***	4.489***
	(0.00131)	(0.0211)	(0.0443)	(0.00153)	(0.0248)	(0.0501)
$Region_{t-1}$	0.0538***	1.066***	2.691***	0.0405***	0.898***	2.138***
	(0.00110)	(0.0226)	(0.0555)	(0.00120)	(0.0286)	(0.0640)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	185,335	185,335	185,335	185,335	185,335	185,335
R-squared	0.863	0.817	0.817	0.870	0.852	0.850
Firm Fixed Effect	No	No	No	Yes	Yes	Yes
Time Effect	No	No	No	Yes	Yes	Yes

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

conditional on whether a given firm has penetrated (or shortly thereafter penetrates) any country in the same region.

The leap from unconditional entry probability to conditional entry probability is useful in that it shows the high entry correlation between countries within the same region. The variation in conditional entry probabilities across countries within each region further reveals much additional information. For example, the conditional entry probabilities of countries like the USA, Russia, and Australia are higher than 85%, which is a signal that those countries are the dominant factor in inducing firms to export their respective regions: once a firm appears in the region, in other words, it will be very likely to appear in those dominant countries – or to have entered one of those countries within the intention of expanding throughout the region. In the Western Europe region, the 5 largest central countries – France, Germany, the UK, Italy, and Spain – have larger conditional entry probabilities; exporters will likely penetrate those countries first and then spread to the surrounding smaller countries (within the region) and Scandinavia. As a result, the entry probability fades as a country becomes more and more remote from this region's center.

Table 6: Entry Probability of Countries/Geos

Country/Geo	Region	# of Entrants	Entry Probability (%)	
			Unconditional	Conditional
China, Mainland	China	49	15.26	100.00
Korea	Japan & Korea	29	9.03	65.91
Japan	Japan & Korea	28	8.72	63.64
Russia	Eastern Europe	70	21.81	85.37
Ukraine	Eastern Europe	59	18.38	71.95
Indonesia	Southeast Asia	58	18.07	61.70
Malaysia	Southeast Asia	44	13.71	46.81
Thailand	Southeast Asia	41	12.77	43.62
Philippines	Southeast Asia	39	12.15	41.49
Singapore	Southeast Asia	37	11.53	39.36
Taiwan	Hong Kong & Taiwan	41	12.77	87.23
Hong Kong	Hong Kong & Taiwan	34	10.59	72.34
Mexico	Latin America 1	40	12.46	81.63
Brazil	Latin America 1	30	9.35	61.22
Argentina	Latin America 1	25	7.79	51.02
Colombia	Latin America 2	25	7.79	86.21
Chile	Latin America 2	23	7.17	79.31
Venezuela	Latin America 2	20	6.23	68.97
USA	North America	46	14.33	97.87
Canada	North America	32	9.97	68.09
Australia	Pacific	33	10.28	86.84
New Zealand	Pacific	25	7.79	65.79
India	India	88	27.41	100.00
Pakistan	Pakistan	29	9.03	100.00
France	Western Europe	83	25.86	68.60
United Kingdom	Western Europe	78	24.30	64.46
Germany	Western Europe	77	23.99	63.64
Italy	Western Europe	72	22.43	59.50
Spain	Western Europe	67	20.87	55.37
Belgium	Western Europe	59	18.38	48.76
Austria	Western Europe	58	18.07	47.93
Netherlands	Western Europe	57	17.76	47.11
Switzerland	Western Europe	56	17.45	46.28
Portugal	Western Europe	52	16.20	42.98
Denmark	Western Europe	48	14.95	39.67
Sweden	Western Europe	44	13.71	36.36
Norway	Western Europe	42	13.08	34.71
Ireland	Western Europe	39	12.15	32.23
Finland	Western Europe	35	10.90	28.93

4.2.2 Entry Dynamics Across Regions

Firms explore a new region by penetrating a country and then using it as a base from which to spread into countries in the same region. Moreover, when firms first enter a new region, they tend to choose that region based on its having similar consumer preferences and/or sharing a culture with the regions they have already penetrated. For example, after a Chinese firm designs the mobile phone models suitable to European quality standards and adapts to European marketing strategies, it would be easier for that firm then to penetrate North American countries and Australia.

Given the importance of such similarities, I will first show, in this section, how I define the degree of consumer similarity between any pair of regions and then test whether firms do indeed tend to enter, subsequently, a region similar to the ones they have already penetrated.

Table 7: Correlation Calculation

Quarter	Price Range	Market Share	
		Western Europe	North America
20101	<100		
20101	100-200	12.64%	0.56%
20101	200-400	24.59%	27.61%
20101	400-600	40.26%	56.57%
20101	600+	22.51%	15.27%
...	...	...	...
20162	<100	6.62%	18.02%
20162	100-200	18.80%	20.25%
20162	200-400	20.52%	14.03%
20162	400-600	22.34%	13.51%
20162	600+	31.73%	34.19%

Based on the price range, I nested the smartphone products into 5 groups: USD 0-100, USD 100-200, USD 200-400, USD 400-600, and USD 600+. I also listed the market share of products for each price range in each region, in each quarter. From here, I can find the market share correlation of consuming products of different price ranges between any two regions in my data. Table 7 shows an example of how I find the consumption correlation between Western Europe and North America.

According to the correlation calculation method shown in Table 7, I calculate the consumption correlation between any pair of regions. Table 8, in turn, shows the correlation matrix between any pair of regions in my data. For example, the consumer correlation between Western Europe and North America is 0.8, while it is -0.25 between Western Europe

Table 8: Regional Correlation

Region	CHN	JK	EE	SEA	HT	LA1	LA2	NA	PA	IND	PAK	WE
China	1.00											
Japan & Korea	-0.49	1.00										
Eastern Europe	0.77	-0.47	1.00									
Southeast Asia	0.66	-0.27	0.84	1.00								
Hong Kong & Taiwan	-0.15	0.77	-0.17	-0.01	1.00							
Latin America 1	0.57	-0.19	0.60	0.52	0.18	1.00						
Latin America 2	0.58	-0.29	0.79	0.82	0.02	0.77	1.00					
North America	-0.32	0.82	-0.16	0.02	0.76	0.05	0.08	1.00				
Pacific	-0.22	0.78	-0.23	-0.04	0.79	-0.15	-0.19	0.67	1.00			
India	0.78	-0.62	0.79	0.74	-0.41	0.30	0.59	-0.40	-0.34	1.00		
Pakistan	0.74	-0.48	0.72	0.61	-0.20	0.56	0.60	-0.23	-0.28	0.75	1.00	
Western Europe	-0.04	0.70	0.05	0.13	0.81	0.41	0.28	0.80	0.64	-0.25	0.03	1.00

and India.

As the entry probability of penetrating a region would be higher once a firm has already penetrated a region similar to it, I further use a reduced-form specification to consolidate this regional entry pattern.

$$Pr(Entry_{ijt} = 1) = \beta_1 Entry_{ijt-1} + \beta_2 Corr_{ijt} + F_i + F_j + T_t + \epsilon_{ijt}$$

$Entry_{ijt}$ is the dummy indicator that firm i's products are available in region j in quarter t, and $Corr_{ijt}$ is the regional correlation between region j and its most correlated region that firm i has penetrated after time $t-1$. Apart from these variables, F_i, F_j, and T_t are the firm fixed effect, region fixed effect, and time fixed effect, respectively.

I estimate the reduced-form equation by OLS, Probit, and Logit, respectively, and report the regression results in Table 9. β_2 is the coefficient in which I am interested. All 6 columns report the significant increase of entry probability for a given region once any similar region has been penetrated. The reduced-form results indicate strong evidence that there may be dependence across regions; this is an indication that firms can take advantage of the experience of selling in one region to reduce the barriers when entering a similar region.

Ultimately, both the region-level entry pattern and the country-level entry pattern within each region guide us to build a structural model to capture firms' entry dynamics and conduct a more insightful policy analysis.

Table 9: Entry Correlation across Regions

	$Entry_t$					
VARIABLES	OLS	Probit	Logit	OLS	Probit	Logit
	(1)	(2)	(3)	(4)	(5)	(6)
$Entry_{t-1}$	0.944***	3.713***	6.741***	0.913***	3.625***	6.800***
	(0.00185)	(0.0451)	(0.114)	(0.00217)	(0.0544)	(0.134)
$Corr_t$	0.0156***	0.825***	2.364***	0.0127***	0.814***	2.112***
	(0.00155)	(0.0707)	(0.213)	(0.00166)	(0.0836)	(0.219)
Observations	38,750	38,750	38,750	38,750	38,750	38,750
R-squared	0.913	0.860	0.860	0.916	0.881	0.881
Firm Fixed Effect	No	No	No	Yes	Yes	Yes
Region Fixed Effect	No	No	No	Yes	Yes	Yes
Time Effect	No	No	No	Yes	Yes	Yes
Estimation	OLS	Probit	Logit	OLS	Probit	Logit

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

5 Model

My model builds on the monopolistic competition framework of an industry, as proposed by Head and Mayer (2019), and the dynamic entry and exit model in continuous time, as presented by Arcidiacono, Bayer, Blevins, and Ellickson (2016).

5.1 Environment

In this scenario, each firm works as a single agent to expand its business and maximize its profits across the whole world. The world consists of countries whose governments independently permit firms to sell within their territories. Firms will consider countries that are geographically close, that are culturally similar, and that share high entry correlations as belonging to a single region.

Firms are endowed with productivity, the locations of their headquarters' "birthplaces", and their major sourcing locations. They must wait for opportunities to move and take actions, and they encounter four stages of entry decisions - along with the related decision costs - as follows [5]:

- Stage 1: Region-Level Entry

[5]See Appendix Section 9.4 to find an example picture of how firms move in my model.

A Poisson arrival process governs when each firm can move to organize a marketing team and build a distribution and research development center for a new specific region or, alternatively, when the firm can do nothing. The cost of organizing a marketing team and building a distribution and research center in a new region can be seen as the sunk cost of entering that region.

- Stage 2: Country-Level Entry

  Conditional on having paid the sunk cost to enter a new region, another Poisson arrival process governs when the firms' marketing team can negotiate with the governments of the countries in that region to obtain the licenses, advertise to build their brand, and settle down the retail network in each country so that they can officially start conducting business there. The cost of this stage can be considered the sunk cost to initiate business in a new country.

- Stage 3: Operation in Each Country

  Conditional on having paid the sunk cost to enter a new country, each firm then needs to pay a recurring fixed cost in order to keep advertising and to maintain the production line and delivery network in each country during each period. However, if the incurred fixed cost is higher than the expected profit for any given country after observing the market demand shock, then the firm's products will not be available in that country during that period.

- Stage 4: Demand and Supply

  Conditional on having decided to sell products in a given country during a given period, a firm then realizes its manufacture and shipping cost shocks, and it prices its products in each market to make profits.

5.2 Demand and Supply

5.2.1 Consumer Demand

Without loss of generality, I assume that each firm sells a single product in each country. In each export destination country n, each consumer m chooses the product of firm i to minimize p_{in}/ψ_{mi} where p_{in} is the price of firm i's product in market n and ψ_{mi} is the taste shock

perceived by consumer m to each product i. I parameterize ψ_{mi} to follow Frechet distribution with parameter η, $Pr(\Psi \leq \psi) = exp(-\psi^{-\eta})$. The probability consumer m chooses firm i's product from the total firm set I_n of firms available in n is given by $(p_{in}/P_n)^{-\eta}$, where $P_n = (\sum_{i \in I_n} p_{in}^{-\eta})^{-\frac{1}{\eta}}$. As a result, quantity demanded for firm i in market n is given by

$$q_{in} = (\frac{p_{in}}{P_n})^{-\eta} Q_n$$

where Q_n is the total market demand of cell phone in country n.

Under monopolistic competition and the property of elasticity, the delivered price is a constant markup $\frac{\eta}{\eta-1}$ of marginal cost. That is $p_{in} = \frac{\eta}{\eta-1} c_{in}$, where c_{in} is the final delivered price of a firm i's product in country n. Taking it into the quantity demand function, I have the quantity demand form as,

$$q_{in} = (\frac{\eta}{\eta - 1} c_{in})^{-\eta} Q_n P_n^{\eta}$$

Here, I did not add the time subscript t to simply the notation.

5.2.2 Marginal Cost of Firms' Products

Firms employ labor to transform the intermediates to final goods, and the productivity of each firm determines the efficiency. So the final product is a composite of assembly labor manufacture and intermediates. If w_l and w_i denote the costs of a composite factor in the assembly labor cost and intermediate cost, respectively. I define the combined cost of inputs to be expressed as $w_l^{\alpha} w_i^{1-\alpha}$. From the characteristics of the Cobb-Douglas function, α is the cost share of assembly labor work in a unit of final good.

Each firm i is endowed with its productivity φ_i. Amid the manufacture and shipping process, each product of firm i meets a cost shock z_{ilnt} if it is manufactured in location l and delivered in destination market n at period t. In addition, for any mobile phone firm i originated from headquarter country h, assembled in country l and delivered in country n, its final delivered cost would meet three dimensions of frictions, namely, γ_{hl}, τ_{ln} and δ_{hn}. γ_{hl} can be seen as the productivity efficiency loss transferred from the headquarter h to the assembly country l. τ_{ln} is the traditional iceberg cost such as tariff and shipping cost from the manufacture location l to the destination market n. δ_{hn} captures variable distribution

and marketing cost friction between headquarter h and destination market n. For example, selling a product in a country that shares the same language or similar culture with the headquarter country would be easier than selling it in a distant and unfamiliar cultural environment.

To sum up, the cost of each unit of firm i's product which is assembled in country l and sold in country n has a function form as

$$c_{ilnt} = \frac{w_{lt}^{\alpha} w_i^{1-\alpha}}{\varphi_i z_{ilnt}} \gamma_{hl} \tau_{ln} \delta_{hn}$$

Here, the headquarter h will be determined as firm i is identified.

5.2.3 Firm Revenue and Profit

As a result, the revenue of firm i in country n at time t conditional on entry is

$$r_{int} = p_{int} q_{int} = (\frac{\eta}{\eta - 1} \frac{w_{lt}^{\alpha} w_i^{1-\alpha}}{\varphi_i z_{ilnt}} \gamma_{hl} \tau_{ln} \delta_{hn})^{1-\eta} P_{nt}^{\eta} Q_{nt}$$

Taking log of the revenue function and I get,

$$log(r_{int}) = \kappa_{lt} + (\eta - 1) log\varphi_i + (\eta log P_{nt} + log Q_{nt}) + (1 - \eta)(log\gamma_{hl} + log\tau_{ln} + log\delta_{hn}) + (\eta - 1) log z_{ilnt}$$

where

$$\kappa_{lt} = (1 - \eta) log(\frac{\eta}{\eta - 1}) + (1 - \eta)(\alpha log w_{lt} + (1 - \alpha) log w_i)$$

Parameterize the cost shock z_{ilnt} to follow an i.i.d. log-normal distribution, and I get a log-linear relationship between revenue, firm productivity, destination country-time fixed effect, production-time fixed effect and frictions between headquarter, assembly, and destination market locations.

Define π_{int} is the sales profit firm i can make in country n at time period t, I have $\pi_{int} = r_{int}/(\eta - 1)$ which is determined by the revenue r_{int} and the markup $1/(\eta - 1)$.

5.3 Operation in Each Country

5.3.1 Fixed Cost

To maintain the sales in each country at each period, firms need to pay for recurring fixed costs to keep advertising, arrange production lines, and delivery networks to operate in each country during each period. But if the incurred fixed cost is higher than the expected profit after observing the market demand shock, their products won't be available in the country during that period. If an exogenous shock, such as a flood and hurricane, make a firm exit the market, the firm need not pay for the country-level sunk entry cost again to access the market as the relationship with local government and retailers and the brand has been built.

I assume there is a fixed entry cost for each firm, which has a function form as $F_{int} = F_n \epsilon_{int}$. The fixed cost multiplier, F_n, shows the cost multiplier relating to each given firm i and destination country n. And ϵ_{int} is the fixed cost shock, i.i.d. over time, which has the log-normal distribution with mean μ_f and variance σ_f.

So the probability of firm i's products available in the country n conditional on it has already entered the country is

$$Pr(1_{int} = 1) = Pr(E[\pi_{int}] > F_{int}) = \Phi(\frac{logE[\pi_{int}] - logF_n - \mu_f}{\sigma_f})$$

where 1_{int} is the indicator firm i is available in country n at time t.

5.3.2 Expected Profit in Each Country

The expected profit firm i conditional on it would be willing to sell its products in country n at time t is,

$$E(\pi_{int}) * Pr(1_{int} = 1) - E(F_{int}|1_{int} = 1)$$

According to the property of log-normal distribution, the expected fixed costs conditional on the firm i's entry of country n is

$$E[F_{int}|F_{int} < E[\pi_{int}]] = E[F_n \epsilon_{int}|F_{int} < E[\pi_{int}]] = F_n e^{\mu_f + 0.5\sigma_f^2} \frac{\Phi(z_{int} - \sigma_f)}{\Phi(z_{int})}$$

where $z_{int} = (logE[\pi_{int}] - [\mu_f + log(F_n)])/\sigma_f$.

5.4 Enter a New Country

5.4.1 Sunk Cost

Conditional on having organized a marketing team and built a distribution and research development center in a specific region, a Poisson arrival process governs when the marketing team can negotiate with the governments of the countries they had not penetrated to get the license, make advertisement to build their brand and settle down the retail network in each country to start their business. This stage's cost can be considered the sunk cost to initiate the business in a new country. Once a given firm has paid sunk entry cost to a given country, its future sales in that country is no longer a dynamic problem.

I assume there is a sunk cost S_{int} for each firm i when receiving an opportunity to enter country n at time t. The sunk cost follows an exponential probability density distribution $f(S_{int}) = \frac{1}{S_n} e^{-\frac{1}{S_n} S_{int}}$ where S_n is entry sunk cost base for destination country n. For each firm i's potential penetration decision of country n, I assume each firm forms an expectation of future market demand and makes its penetration decision based on the demand expectation. Define $EV1_{in}$ is the value of further payoffs once firm i has paid the sunk cost in country n and $EV0_{in}$ is the value it has not. Once firm i got an opportunity to enter country n at time t, the probability it makes the penetration is

$$Pr(1_{int} = 1) = Pr(EV1_{in} - S_{int} > EV0_{in})$$

Furthermore, according to the property of exponential distribution, the expected sunk cost firm i needs to pay if it did pay for the sunk cost to enter the country is[6],

$$E(S_{int}|1_{int} = 1) = S_n * p_{in}^{01} - (EV1_{in} - EV0_{in}) * p_{in}^{00}$$

where p_{in}^{01} refers to the probability that firm i chose to pay for the sunk cost to enter country n conditional on a move opportunity and p_{in}^{00} refers to the probability that firm i chose not to pay for the sunk cost to enter country n conditional on a move opportunity.

As I have drawn the expected profit in each country at each period, the value of further

[6] See Appendix Section 9.8

payoffs once firm i has paid the sunk cost in country n at time t, $EV1_{in}$ is

$$EV1_{in} = \frac{E(\pi_{in}) - E(F_{int}|1_{int} = 1)}{1 - \rho}$$

where ρ is the discount rate. And the value it has not entered country n has the function form as,

$$EV0_{in} = \frac{p_{in}^{01}[EV1_{in} - E(S_{int}|1_{int} = 1)]}{1 - \rho(1 - p_{in}^{01})} = \frac{p_{in}^{01}[EV1_{in} - S_n * p_{in}^{01} + (EV1_{in} - EV0_{in}) * p_{in}^{00}]}{1 - \rho(1 - p_{in}^{01})}$$

Thus, $EV1_{in}$ can be deduced from the expected profit in each country from the last section and $EV0_{in}$ has a relationship between $EV1_{in}$ and the sunk cost base value S_n. Once we know S_n, we will also get the $EV0_{in}$ and as a result the probability p_{in}^{01} firm i pays the sunk cost to make the entry decision conditional on move opportunity. Matching the observed firm entry probability with the model predicted entry probability will help us identify the sunk cost parameters S_n.

5.4.2 Expected Profit in Each Region

Once a firm paid the sunk cost to enter a region, such as building a distribution center and organizing a marketing team, the firm's team of the region will continuously contact the entry issues and wait for the response from the governments and local retailers to get permitted to enter each country in the region. The value firm i gains from a specific country n after entering the region, is $EV0_{in}$ and the equivalent instant payoff from entering country n is $(1 - \rho)EV0_{in}$. As a result, the expected instant payoff firm i get after entering a region r is the sum of the payoff from each specific country n in the region r,

$$\pi_{ir} = \Sigma_{n \in r}(1 - \rho)EV0_{in}$$

With the instant payoff for firms to enter each specific region π_{ir} identified, I can go back to stage 1 and solve the optimization problem of how firms make export dynamics across regions.

5.5 Entry Decision Across Regions

Firms are endowed with their characteristics (productivity, etc.) and headquarter birthplace. A firm needs to wait for an opportunity to act if it plans to make an additional penetration of other regions. A Poisson arrival process governs when each firm can move to organize a marketing team and build a distribution and research development center in a new specific region or do nothing. The cost of organizing a marketing team and building a distribution and research center in a region can be seen as the sunk cost to enter a new region.

5.5.1 State of Entry

The definition of a state of entry is important to solve the optimization of choosing entry sequences. I enumerate all possible states by an integer scalar index $k = 1, ..., K$. The entry state of each firm at each instant is s_k. It indicates which regions have been penetrated at the instant t. With the 40 countries' data, I have divided them into 12 regions, namely, North America, Latin America 1, Latin America 2, Western Europe, Pacific, Eastern Europe, China, Japan & Korea, Hong Kong & Taiwan, Southeast Asia, India, and Pakistan. I use a 12-dimension vector containing the entry dummy for each region to measure regional entry state. More specifically, I use a 12-dimension dummy indicator vector to correspond to the entry state of (Na, La1, La2, We, Pa, Ee, Chn, Jk, Ht, Sea, In, Pk). For example, when Apple only sold its iPhone products in the USA, Germany, France and UK, its state was (1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0).

5.5.2 Value Function

π_{ik}, which is the expected instant payoff conditional on having a state k of penetration towards regions, can be defined as the sum of the expected flow profit of firm type i in all the regions r included in state k. It can be seen as $\pi_k = \sum_{r \in k} \pi_r$. I have deduced π_r from the stage sunk cost estimation. A Poisson process with rate parameter λ governs when a firm can move. When a move arrives, the firm chooses an action j from the discrete choice set $A = \{0..., J\}$. Each action j will be one option to enter a new specific region or keep the state and do nothing. As a result, an action of entering changes a firm's state of entry.

A random move arrival process reflects the stochastic timing of recruiting high-skilled

workers to manage the overseas business and negotiate with foreign landlords to build the marketing and research facilities. When a firm gets a chance to move and chooses an action j, it would also receive an additive instantaneous payoff $\psi_{ijk}+\varepsilon_{ijkt}$. The instantaneous payoff can be seen as the entry cost when a firm is penetrating. ψ_{ijk} is the mean instantaneous payoff associated with firm type i making the choice j in state k, which can be considered as the regional entry cost. ε_{ijkt} is the instantaneous payoff shock. I define the function $l(j,k)$ to give the entry state conditional on any firm taking action j in state k.

Then the value function for firm i in state k is given by:

$$V_{ik} = \frac{\pi_{ik} + \lambda Emax_j\{V_{i,l(j,k)} + \psi_{ijk} + \varepsilon_{ijkt}\}}{1-\rho+\lambda}$$

I have shown how to estimate the π_{ik} in the last subsection. If I can estimate the instantaneous payoff ψ_{ijk}, I can solve the model and track firms' entry sequences from the model. Let σ_{ijk} denote the probability that the firm of type i optimally chooses j in state k, the proposition below proposed from Hotz and Miller (1994) and Arcidiacono, Bayer, Blevins, and Ellickson (2016) would help us identify the parameters,

Proposition 1 For a given state k, suppose that for any state $l \neq k$ with the state transition rate $q_{kl} > 0$, there exists a state $k*$ attainable from both k and l. Then there exists a function $\Gamma_k(\psi, \sigma)$ such that

$$(1-\rho)V_k = \pi_k + \Gamma_k(\psi, \sigma)$$

The propositions above show that the value function can be written as a linear function of the payoffs, costs of making choices, and conditional choice probabilities. Once I can assume the parameterization of the costs and cost shocks, I can deduce the specific function form Γ and solve this equation to back out the value function.

6 Empirical Implementation

I estimate the model by stages to solve the optimization problem.

1. Estimate the parameters of demand and firm's delivery cost parameters to back out

the expected profit each firm can make conditional on entry.

2. Obtain the fixed cost parameters in each country for firms to maintain the business.

3. Estimate the sunk cost to enter each country after firms settle down in a region.

4. Non-parametrically estimate the transition rate of regional entry states, acquire the regional entry cost parameters which determine firms' entry decisions of regions taking the regional entry state transition rates as given.

In the following section, I will show my estimation procedure and the results.

6.1 Step 1: Estimate Demand and Supply

As the section of demand and supply shows, the log of firm's revenue has a function form as,

$$log(r_{int}) = \kappa + (\eta - 1)log\varphi_i + (\eta logP_{nt} + logQ_{nt}) + (1-\eta)(log\gamma_{hl} + log\tau_{ln} + log\delta_{hn}) + (\eta - 1)logz_{ilnt}$$

where

$$\kappa = (1-\eta)log(\frac{\eta}{\eta - 1}) + (1-\eta)(\alpha logw_{lt} + (1-\alpha)logw_i)$$

φ_i can be treated as firm i's specific productivity level. $\eta logP_{nt} + logQ_{nt}$ can be considered as a destination country-time fixed effect. $(1-\eta)(\alpha logw_{lt})$ can be considered as the production-time fixed effect. I parameterize the production and delivery shock z_{ilnt} to follow a log-normal distribution. If I can parameterize the trade friction terms γ_{hl}, τ_{ln} and δ_{hn}, an OLS regression can help us identify the parameters and back out the expected profit of each firm in each country. I now take care of the parameterization.

6.1.1 Parameterization

I specify the frictions governing headquarter input transfer cost (γ), trade cost (τ) and variable marketing cost (δ) to be exponential functions of the observable determinants denoted X_{hl}, X_{ln} and X_{hn}:

$$\tau_{ln} = exp(X'_{ln}f), \gamma_{hl} = exp(X'_{hl}g), \delta_{hn} = exp(X'_{hn}d)$$

where f, g and d are vectors of the primitive friction cost parameters.

The X vectors include the standard explanatory variables used in gravity equations: home, distance, and common language. $Home_{hl}$ equals one when the plant is located in the headquarters country. $Home_{ln}$ indicates that the assembly plant is in the same country as where the cell phone is sold. $Home_{hn}$ turns on when the consumers and the brand share the same home country. *Distance* is the average number of kilometers on a great-circle route between the main cities in the corresponding countries. *Language* indicates that the countries share an official language.

6.1.2 Results

Table 10 shows the regression result of the gravity equation. With a firm fixed effect, country-time fixed effect, and production location-time fixed effect, the friction variables' estimates make sense. There is a negative relationship between distance and revenue: the longer the distance, the larger the productivity losses, shipping costs, and marketing costs. There is a positive relationship between the same language and revenue: sharing the same language reduces communication barriers. The only outside estimate is the negative estimator of the home dummy between the headquarter and assembly locations. It can reflect firms who positively seek overseas production can acquire cheaper cost and larger revenue while the firms who are conservative and insist producing at home would be less productive. With the regression results in this part, I can back out the revenue each firm i can earn in each destination country n at each time t.

Table 10: OLS of the Gravity Equation

VARIABLES	Log of Revenue
Home Country of Headquarter & Assembly	-1.316***
	(0.348)
Home Country of Assembly & Destination	0.143
	(0.119)
Home Country of Headquarter & Destination	1.200***
	(0.0669)
Same Language of Headquarter & Assembly	0.115
	(0.344)
Same Language of Assembly & Destination	0.330***
	(0.0673)
Same Language of Headquarter & Destination	0.130***
	(0.0379)
Log of Distance of Headquarter & Assembly	-0.197***
	(0.0558)
Log of Distance of Assembly & Destination	-0.330***
	(0.0358)
Log of Distance of Headquarter & Destination	-0.0112
	(0.0178)
Constant	6.375***
	(1.000)
Firm Productivity Fixed Effect	Yes
Headquarter Country is An Assembly Hub Dummy	Yes
Destination Country-Half Year Fixed Effect	Yes
Production Location-Half Year Fixed Effect	Yes
Observations	25,284
R-squared	0.707

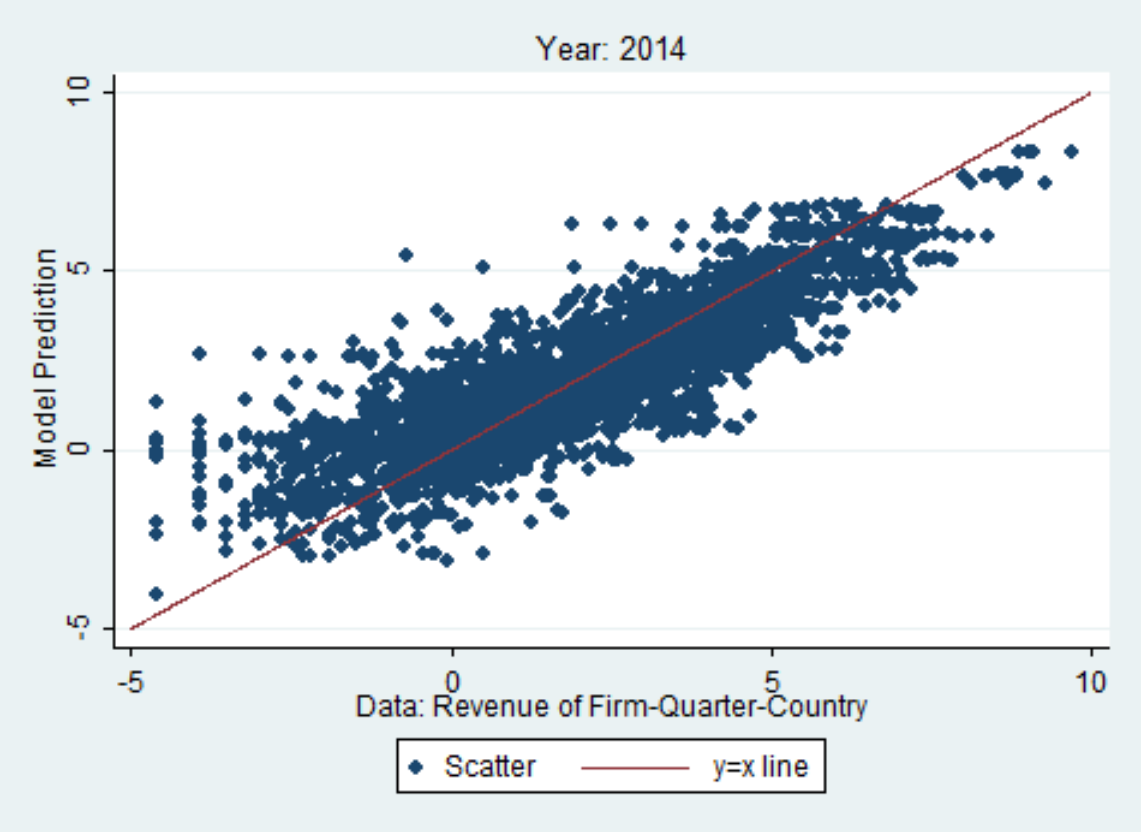
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.1.3 Fit of the Gravity Estimation

Figure 2 shows the fit of the gravity estimation in the year 2014. The y-axis scatters the model predicted log of revenue each firm can make in each country, and the x-axis shows the data observed log of revenue. The high density around the $y = x$ line shows the excellent fit of the gravity model estimation. The fit also indicates the validity of using the gravity

model results to predict the revenue each firm can make in each country.

Figure 2: Fit of Gravity Model



6.1.4 Calibration of Markup and Profit

With the expected revenue, I then calibrate the elasticity and markup to deduce the profits. Based on the structural form of consumer demand in my model, the profit $\pi_{int} = \frac{1}{\eta-1} r_{int}$ under the monopolistic competition. One way to estimate η is to use the tariff information. As in the gravity equation,

$$log(r_{in}) = \kappa + (\eta-1)log\varphi_i + (\eta log P_n + log Q_n) + (1-\eta)(log\gamma_{hl} + log\tau_{ln} + log\delta_{hn}) + (\eta-1)logz_{il}$$

And I have parameterized $\tau_{ln} = exp(X'_{ln}f)$, where f is a vector of the primitive friction cost parameters, and the X vector includes the standard explanatory variables used in gravity equations: home, distance, and common language. If the tariff variable is included, the estimator of the tariff variable in the equation will tell us $1-\eta$.

Table 11: Markups by Firm from Other Source

Rank	Brand	Headquarter	Average Markup	Sales Units Share in 2016
1	Samsung	South Korea	0.073	24.35%
2	Apple	USA	0.137	16.90%
3	Huawei	China, Mainland	0.047	7.16%
4	Xiaomi	China, Mainland	0.045	5.14%
5	LG	South Korea	0.053	4.73%
6	OPPO	China, Mainland	0.044	3.88%
7	Lenovo	China, Mainland	0.042	3.73%
8	vivo	China, Mainland	0.042	3.26%
9	ZTE	China, Mainland	0.044	3.09%
10	Coolpad	China, Mainland	0.041	2.56%
11	Motorola	USA	0.049	2.36%
12	Sony	Japan	0.052	2.24%
13	Alcatel	France	0.049	1.95%
14	Nokia	Finland	0.045	1.52%
15	Gionee	China, Mainland	0.037	1.39%
16	Micromax	India	0.038	1.34%
17	HTC	Taiwan	0.046	1.25%
18	Meizu	China, Mainland	0.038	0.93%
19	ASUS	Taiwan	0.048	0.92%
20	Lava	India	0.042	0.86%

Data Source: Xie, Re-exploring Markups and the Gains from International Trade, 2020

Meanwhile, the country-time fixed effect in the regression determines each destination country's most favored nation duty at each period. However, conditional on controlling the country-time fixed effect, there is not much variation of tariff rate in my specification. So I calibrate the markup by referring to a paper in which the IO's nested logit demand form is applied to the same data set and back out firms' markup decisions towards their products in an IO estimation strategy. Table 11 shows the top 20 mobile phone firms' markups and their market share in the world in the year of 2016. Except for Apple and Samsung, most smartphone firms price around 4-5% to be their markup, which is consistent with the reports of the media. [7]. Thus, I calibrate the markup to be 5% for every cell phone firm in the estimation. With the markup calibrated, I predict the profit each firm i make in each destination country n at each time t.

[7]See Appendix section 9.4.

6.2 Step 2: Estimate the Fixed Cost

As the section of firm's entry decision to pay for a fixed cost to maintain the regular operation shows, the probability of firm i selling in country n at time t conditional on having entered the country is the probability the realized fixed cost is smaller than the expected profit,

$$Pr(1_{int} = 1) = Pr(E[\pi_{int}] > F_{int}) = \Phi(\frac{logE[\pi_{int}] - logF_n - \mu_f}{\sigma_f})$$

where $E[\pi_{int}]$ is the expected profit firm i can make in country n at time t after observing the market demand shocks (destination country-time fixed effect), which can be deduced from the gravity model estimation. F_n is the fixed entry cost multiplier relating to destination country n. The fixed entry cost shock has the log-normal distribution with mean μ_f and variance σ_f.

A Probit MLE estimation would estimate the $log(F_n) + \mu_f$ for all the countries in my data and the fixed entry cost shock variance σ_f. With those parameters estimated, I am able to back out the mean of the quarter fixed cost each firm incur in each country.

6.2.1 Results

The MLE estimation gives us estimates of maintaining fixed cost parameters. σ_f is estimated to be 3.05. Table 12 lists the average quarterly fixed cost to maintain cellphone sales in each destination country deduced from estimated $log(F_n) + \mu_f$ in each country n and σ_f. Most of the quarterly fixed costs among countries range from 17 thousand dollars (Colombia) to 844 thousand dollars (USA). Japan's fixed cost is large as its market is large, but only the iPhone and five domestic firms keep significant sales. Several strong brands once had to exit from the market. It indicates the difficulty of beating the local firms and maintaining sales in Japan. The more populated the country, the higher the fixed costs are, and the more popular the destination country as an assembly location (China, India, Brazil, Argentina, Venezuela), the higher fixed costs are.

Table 12 also shows the data observed exit rate and model predicted exit rate due to high fixed cost draws. The excellent fit of the observed and model-predicted exit rate shows the validity of fixed cost estimation to capture firms' activity in each market after paying the sunk cost to penetrate a market.

Table 12: Average Estimated Quarterly Fixed Cost by Destination Country

Country/Geo	Mean of Fixed Cost	Exit Rate		Country/Geo	Mean of Fixed Cost	Exit Rate	
		Data	Model			Data	Model
Argentina	509.07	8.61	7.39	Mexico	182.68	3.32	3.48
Australia	149.22	4.03	4.06	Netherlands	158.34	9.1	8.81
Austria	105.69	7.7	7.83	New Zealand	52.43	4.46	4.64
Belgium	103.28	9.99	8.2	Nigeria	105.93	10.75	9.52
Brazil	400.11	3.48	3.99	Norway	135.40	7.58	7.96
Canada	187.33	7	4.64	China, Mainland	607.97	5.03	2.88
Chile	172.38	5.44	6.49	Pakistan	115.93	5.16	4.55
Colombia	17.19	1.17	1.49	Philippines	89.09	7.05	4.85
Denmark	132.60	10.86	8.58	Portugal	55.57	9.03	6.69
Finland	88.73	10.06	8.44	Russia	163.26	5.29	5.25
France	155.42	6.39	5.67	Singapore	92.98	5.7	5.44
Germany	145.15	6.26	5.37	Spain	128.69	6.24	5.5
Hong Kong	170.48	5.8	5.76	Sweden	153.40	7.63	7.62
India	265.50	5.74	5.72	Switzerland	180.56	12.63	10.79
Indonesia	200.92	8.57	6.64	Taiwan	121.56	7.2	5.4
Ireland	94.38	8.43	8.41	Thailand	127.87	7.48	5.4
Italy	214.79	9.73	7.64	USA	844.75	3.49	3.5
Japan	2212.16	7.31	5.54	Ukraine	153.57	12.09	11.25
Korea	779.64	7.55	8.9	United Kingdom	177.86	8.7	5.83
Malaysia	129.42	5.81	5.81	Venezuela	221.38	9.15	8.43

Fixed cost is measured in thousands of US dollars and exit rate is measured in percentile.

6.2.2 Expected Profit in Each Country

As σ_f and $log(F_n) + \mu_f$ in each country have been estimated, I can construct the expected profit of any firm i in each country at each period if it has paid the sunk cost to enter the country. As I show, the expected profit firm i conditional on it would be willing to sell its products in country n at time t is,

$$E(\pi_{int}) * Pr(1_{int} = 1) - E(F_{int}|1_{int} = 1)$$

and I have

$$E[F_{int}|F_{int} < E[\pi_{int}]] = E[F_n\epsilon_{int}|F_{int} < E[\pi_{int}]] = F_n e^{\mu_f + 0.5\sigma_f^2} \frac{\Phi(z_{int} - \sigma_f)}{\Phi(z_{int})}$$

where $z_{int} = (logE[\pi_{int}] - [\mu_f + log(F_n)])/\sigma_f$.

The gravity estimation results can help us back out the expected profit each firm can make in each country $E(\pi_{int})$. With the estimated fixed cost parameters σ_f and $log(F_n)+\mu_f$, I can also identify $Pr(1_{int} = 1)$ and $E(F_{int}|1_{int} = 1)$. With the information above, I can predict firms' expected profits conditional on paying for the sunk cost to penetrate a country

and analyze how firms make country-level penetrations for the next stage.

6.3 Step 3: Estimate the Sunk Cost to Each Country

I calibrate that firms discount their future payoffs at a rate of $\rho = 0.95$. I have got $EV1_{in}$ the value of further payoffs once firm i has paid the sunk cost in country n to be,

$$EV1_{in} = \frac{E(\pi_{in}) * Pr(1_{int} = 1) - E(F_{int}|1_{int} = 1)}{1 - \rho}$$

I assume each firm expects future market demand and makes its penetration decision based on the demand expectation. So when I estimate $E(\pi_{in})$, I assume that firms uses the average destination country-time fixed effect to form their expectations of market demand shocks[8]. I back out the $E(\pi_{in}) - E(F_{int}|1_{int} = 1)$ from last section, so does the $EV1_{in}$.

Meanwhile, the probability firm i has not paid the sunk cost in country n meets an opportunity and pays the cost to enter is

$$Pr(1_{int} = 1) = Pr(S_{int} < EV1_{in} - EV0_{in}) = F_{S_n}(EV1_{in} - EV0_{in}) = p_{in}^{01}$$

where $F(.)$ is the cumulative density function of the entry sunk cost shock, which follows an exponential distribution with parameter S_n. As a result, conditional on S_n, there is a specification between $EV0_{in}$ and p_{in}^{01} from this equation. Furthermore, according to the specification of $EV0_{in}$, I have

$$EV0_{in} = \frac{p_{in}^{01}[EV1_{in} - S_n * p_{in}^{01} + (EV1_{in} - EV0_{in}) * (1 - p_{in}^{01})]}{1 - \rho(1 - p_{in}^{01})}$$

As a result, I get another specification between $EV0_{in}$ and p_{in}^{01} from the equation above.

Conditional on S_n, I can back out $EV0$ and p^{01} for each firm i's penetration attempt to country n from the two relationship equations between $EV0$ and p^{01}. I can also construct four sets of moments, namely $m_1(n), m_2(n), m_3(n), m_5(n)$ to match the model predictions with data observations. Moreover, $m_1(n)$ represents the fraction of firms penetrating each specific country n within one year after penetrating any country in the region country n

[8]When predicting the expected profit in this part, I made some additional assumptions about the firms' production location decisions. When firms export to Brazil and Argentina, they need to build local plants to avoid the high tariff rate. When firms export to countries other than Brazil and Argentina, they rely on their primary sourcing locations to assemble their products and then deliver their products from their plants.

belongs. And $m_2(n), m_3(n), m_5(n)$ represents of the entry fraction in 2 years, 3 years and 5 years. A Simulated Method of Moments estimation would estimate the S_n for all the countries in my data, and the sunk costs firms incur by country.

Table 13: Sunk Cost Estimates by Destination Country

Country/Geo	Region	S_n	Entry Fraction (%)			
			1 Year		3 Years	
			Data	Model	Data	Model
Japan	Japan & Korea	40.53	50.00	42.88	56.82	63.90
Korea	Japan & Korea	19.59	38.64	31.37	50.00	53.93
Russia	Eastern Europe	4.55	65.00	46.07	67.50	75.44
Ukraine	Eastern Europe	2.40	30.00	26.84	51.25	50.46
Indonesia	Southeast Asia	12.84	47.25	30.52	54.95	57.79
Thailand	Southeast Asia	16.98	34.07	21.48	36.26	44.33
Philippines	Southeast Asia	11.10	30.77	21.26	37.36	44.09
Malaysia	Southeast Asia	22.94	30.77	18.47	32.97	40.09
Singapore	Southeast Asia	17.40	26.37	17.34	31.87	38.20
Taiwan	Hong Kong & Taiwan	0.71	80.00	72.58	86.67	92.90
Hong Kong	Hong Kong & Taiwan	7.93	48.89	37.63	62.22	65.84
Mexico	Latin America 1	7.29	70.83	53.97	72.92	81.67
Brazil	Latin America 1	31.01	54.17	36.97	58.33	62.13
Argentina	Latin America 1	36.49	22.92	24.46	47.92	46.79
Chile	Latin America 2	5.24	75.86	40.83	75.86	68.05
Colombia	Latin America 2	3.90	75.86	47.32	79.31	75.95
Venezuela	Latin America 2	2.79	62.07	43.32	62.07	69.57
USA	North America	6.89	83.72	78.37	88.37	96.80
Canada	North America	5.10	55.81	42.76	65.12	69.66
Australia	Pacific	2.96	75.00	57.76	75.00	85.02
New Zealand	Pacific	13.11	30.56	22.15	38.89	46.00
France	Western Europe	8.14	51.28	32.40	54.70	59.59
Germany	Western Europe	13.94	46.15	27.59	50.43	53.66
United Kingdom	Western Europe	10.77	43.59	28.60	51.28	54.26
Italy	Western Europe	10.73	40.17	23.89	45.30	47.61
Spain	Western Europe	13.39	36.75	22.07	44.44	44.82
Portugal	Western Europe	6.05	29.06	17.11	35.90	36.09
Netherlands	Western Europe	10.46	28.21	17.37	36.75	36.70
Austria	Western Europe	7.40	27.35	15.00	32.48	32.20
Switzerland	Western Europe	6.76	25.64	15.77	34.19	33.43
Belgium	Western Europe	9.93	25.64	14.85	32.48	32.09
Sweden	Western Europe	15.18	23.93	12.35	27.35	27.15
Denmark	Western Europe	9.52	23.08	12.81	29.06	27.97
Ireland	Western Europe	8.52	17.95	10.47	23.93	23.35
Norway	Western Europe	16.96	17.09	9.96	23.93	22.42
Finland	Western Europe	13.18	15.38	9.33	23.08	20.80

Unit: Millions of Dollars

6.3.1 Results

Table 13 lists my estimation of sunk cost parameter S_n by country. As S_n follows the exponential distribution, the value also indicates the mean of sunk cost draw each firm incurs when trying to penetrate each country. In the next four columns, I have also shown the fit of fractions of firms penetrating each specific country conditional on any country's penetration in the same region in one year and three years.

As seen from the table, most sunk cost estimates range from 5 million dollars to 15 million dollars. For countries that impose high tariff rates or regulations towards imported electronic goods like Argentina and Brazil, the sunk cost is high, which shows the potential additional costs to build plants there. The high sunk cost estimates are consistent with their relatively less competitive markets due to the stricter import regulations. The relative high sunk cost estimates in Japan and Korea show the difficulty for firms to build their brand to attract consumers and local retailers from their home country brands to adopt foreign products. The higher sunk cost estimates in Northern European countries such as Finland, Norway, and Sweden than the sunk costs in central-western European countries like Belgium and Austria show that when foreign firms penetrate Western European countries, they will first penetrate large central countries like Germany and France. Then they gradually spread to the surrounding smaller countries like Belgium and the Netherlands. Later, they spread to remote small countries like Sweden and Finland.

My model predicts higher entry probability for each firm's penetration attempt to any country from the smaller sunk cost draw as firms make more and more attempts. The reduction in sunk entry costs by time can be seen as less uncertainty in a more extended period when negotiating with the local government to get the license and local retailers to settle down the marketing lines.

6.3.2 Expected Profit in Each Region

I need to calculate the expected instant payoff firm i gets after entering a region r for the estimation of the next stage. As I showed,

$$\pi_{ir} = \Sigma_{n \in r}(1-\rho)EV0_{in}$$

As I can back out $EV0_{in}$ and $Pr(1_{int} = 1)$ from the two relationship equations, thus I am able to get π_{ir}. With the instant payoff for firms to enter each specific region π_{irt} identified, I can go back to stage 1 and solve the optimization problem of how firms make export dynamics across regions.

6.4 Step 4: Estimate the Region Entry Costs

With the information I get from the past stages, especially π_{ir}, the expected instant payoff firm i get after entering a region r for the next stage of estimation, I can go to the Stage 1 and work at how firms make regional entry decisions now. Then the value function of firm i in state k is given by:

$$V_{ik} = \frac{\pi_{ik} + \lambda Emax_j\{V_{i,l(j,k)} + \psi_{ijk} + \varepsilon_{ijkt}\}}{1 - \rho + \lambda}$$

where k is the state of penetrated regions. I calibrate the discount rate of ρ to be 0.95. π_{ik}, which is the expected instant payoff conditional on having a state k of penetration towards regions, is the sum of the expected flow profit of firm type i in all the regions r included in state k. It can be calculated as $\pi_k = \sum_{r \in k} \pi_r$. I deduce π_r in the last section of the sunk cost of each country. A Poisson process with rate parameter λ governs when a firm can move. I calibrate λ to be one as a firm gets, on average, one opportunity to move in each half year's period. As a reminder, each action j will be one option to enter a new specific region or keep the state and do nothing.

As I have worked out π_{ik}, ρ, λ, and I observe how firms take actions j from the data. I need to work out the additive instantaneous payoff $\psi_{ijk} + \varepsilon_{ijkt}$, which can be seen as the entry cost when a firm is penetrating, to solve the dynamic optimization. Following the method proposed in dynamic estimation literature, I first estimate the entry state transition rate and then estimate the payoff parameters based on the state transition rate.

6.4.1 Nonparametrically Estimate the Entry State Transition Rates

In this step, I estimate the reduced form hazards that capture the rate of change in the regions penetrated by each firm. As σ_{ijk} denotes the rate for firm i choosing action j in state

k and let α denote the vector of all state-specific hazards of firms, which indicates

$$\alpha = (\sigma_{111}, ..., \sigma_{1Jk}, ..., \sigma_{N11}, ..., \sigma_{NJK})$$

In my data, I observe all the events that took place at the end of each quarter. If in a quarter, more than two actions have been taken (e.g., penetration of two regions) by a firm, I can not observe the exact times at which these events occur. For each quarter, I draw $R = 50$ simulated paths, randomly assigned each observed event to a simulated time. From the simulated paths, then I non-parametrically estimate the reduced form hazards of the state transition α.

6.4.2 Estimate Regional Payoff Structural Parameters

I estimate the entry cost parameters that determine firms' entry order decisions of regions taking the reduced form hazards as given. Recall what I have from Proposition 1: for each firm type i, there exists a function $\Gamma_k(\psi, \sigma)$ such that

$$(1 - \rho)V_k = \pi_k + \Gamma_k(\psi, \sigma)$$

The propositions above show that the value of states can be represented by a function of discount rate ρ, state transition rate σ, the instantaneous payoff at each state π, and the ex-ante expected value of choice specific payoff ψ. How to compute the function $\Gamma(\psi, \sigma)$ is crucial. It depends on the distribution of the shock ε and the function form of the cost ψ.

6.4.3 Parameterization

I parameterize the distribution of ε_{ijkt} to follow a Gumbel distribution with scale β and the density function $F(\varepsilon) = exp(-exp(-\varepsilon/\beta))$. According to the property of the Gumbel distribution,

$$Emax_j\{V_{i,l(j,k)} + \psi_{ijk} + \varepsilon_{ijkt}\} = V_{i,l(j',k)} + \psi_{ij'k} + \beta(\gamma - log(\sigma_{ij'k}))$$

where j' is any available choice firm i can make in state k and γ is the Euler constant. It also gives us

$$E\{\psi_{ijk} + \varepsilon_{ijkt} |\ j \textit{ is maximization choice}\} = \psi_{ijk} + \beta(\gamma - log(\sigma_{ijk}))$$

I further parameterize the mean regional cost as $\psi_{ijk} = \psi_{ij} * exp(Corr_{jk}\beta_c)$. The ψ_{ij} follows a functional form as,

$$\psi_{ij} = \begin{cases} exp(\beta_r), & \text{if } j \text{ is penetrating a specific region } r \\ 0, & \text{if } j = 0, \text{ do nothing} \end{cases}$$

Finally, $Corr_{jk}$ is the consumer correlation between region j and its most correlated region in the regions penetrated at state k, and β_c is the coefficient to measure the reduction of the entry cost if the new region being penetrated is similar to a previous export region. Note that I have shown a regional correlation matrix in Table 7.

6.4.4 Estimation Procedure

I put the parameterization specification back to the value function equation. The value of states V_k can be represented by a function of discount rate ρ, instantaneous payoff π_k, mean of regional entry cost ψ, Euler constant γ, state transition rate σ and the scale parameter of the regional cost shock distribution β. I have the reduced form hazard σ_i from the last stage, the expected profit π_{ik} each type i of firm can make in each state k from last section's analysis. Once setting up the vector $\hat{\psi} = (\hat{\beta}_{CHN}, ..., \hat{\beta}_{WE}, \hat{\beta}_c, \hat{\beta})$, I can back out the value function vector of states $\hat{V}_i(\sigma_i) = (\hat{V}_i(\sigma_1), ..., \hat{V}_i(\sigma_K))$ for each firm i at each state k.

With the estimated value of states, I draw the probability firms make their choices under different states. That is, when a firm of type i receive a move arrival at state k, its best response $\delta_i(k, \varepsilon_i) = j$ if $V_{i,l(j,k)} + \psi_{ijk} + \varepsilon_{ijkt} \geq V_{i,l(j',k)} + \psi_{ij'k} + \varepsilon_{ij'kt} \forall j'$. The estimated response probability is $\hat{\sigma}_{ijk} = Pr[\delta_i(k, \varepsilon) = j|k]$.

Finally, I find the best set of cost parameters $\hat{\psi}$ to match the model predicted likelihoods $\hat{\sigma}_{ijk}$ with the data observed state transition rates σ_{ijk} to identify regional cost parameters.

6.4.5 Results

I estimate the regional entry cost reduction of similar consumer correlation β_c to be -1.2 and the cost shock distribution's scale parameter β to be 4.74. Table 14 lists my estimation of sunk cost parameters β_r by region. The column of max entry costs shows the maximum regional entry costs firms need to pay if it had not entered any region similar to this potential penetration region. The min entry costs column shows the minimum regional entry costs conditional on firms that have penetrated the most similar region with this potential region. For example, an American firm would incur an average of 192.69 million dollars if it directly enters China while the average regional entry cost could reduce to 42 million dollars after the firm penetrated India. The estimation results show the regional entry costs could be much smaller if the penetration region shares high consumer correlation with any region the firm has already penetrated. After penetrating the most similar regions, most of the regional entry costs range below 15 million dollars. The high sunk entry costs to China and large Latin American countries indicate the difficulty of designing a product that fits to meet local government and local retailers' requirements.

The last two columns of entry probability show the fit of this stage's estimation. The data column shows the average entry probability on a move opportunity when a firm is observed to penetrate the specific region as the next action. The column of model prediction shows the entry probability for a firm to transfer to the new state predicted by the state value and estimated entry costs when the specific region is the observed additional penetration region.

Table 14: Regional Entry Costs

Region	β_r	Entry Cost		Entry Probability (%)	
		Max	Min	Data	Model
China	4.68	192.69	42.34	45.19	49.03
Japan & Korea	2.85	36.21	6.48	54.96	45.98
Eastern Europe	2.79	28.43	5.95	50.29	48.67
Southeast Asia	3.78	60.51	16.00	45.00	41.50
Hong Kong & Taiwan	3.66	63.97	14.80	47.58	49.54
Latin America 1	4.09	74.88	23.72	41.43	39.81
Latin America 2	3.72	58.25	15.57	50.92	58.29
North America	3.46	51.35	11.88	49.51	59.18
Pacific	1.98	10.85	2.83	54.67	53.94
India	3.21	51.89	9.66	49.38	50.77
Pakistan	3.24	45.35	10.43	48.44	49.78
Western Europe	3.22	34.08	9.55	46.24	49.79

Entry costs are measured in millions of dollars

The regional entry cost is important in a firm's expansion. Combine it with the estimation of country-level sunk entry cost, the understanding of entry costs firms would interesting. From the data, Chinese firms prefer to explore the west from Germany and France. So they need to pay on average 34 million dollars to get to know the consumer preferences of designs and how to deal with the retailer in Western Europe. Its penetration to the European countries, like Germany and France, would be only around 10 million dollars. After gaining experience in Europe, the entry costs to North America and Australia would also be much lower.

7 Counterfactual Analysis

My dynamic optimization estimation is based on the conditional choice probability method (CCP). As common knowledge, the critical advantage of CCP estimation is that it eliminates the need to compute the dynamic optimization's full solution, allowing empirical researchers to estimate relatively high-dimensional optimization problems. Nevertheless, the critical limitation of applying CCP estimation to a high-dimension problem is that it is often impossible to compute the estimated model's counterfactual simulations: that is, CCP estimation simplifies the estimation procedure in general, but the researcher must still solve all possible states' dynamic problems in the counterfactual analysis. Fortunately, the state space of my

model is enormous yet still limited to a computable range and my model can predict each firm's export entry dynamics[9].

7.1 Policy Analysis

This paper was motivated by an interest in illuminating how dynamic entry costs shape our understanding of the externality of trade policies, economic geography, and gains from trade liberalization. The counterfactual analysis follows.

7.1.1 Externality of Trade Policy

5G is a hot communication technology that will profoundly influence everyone's daily life. Meanwhile, the adoption of electronic equipment that utilizes 5G technology has implications for data privacy and national security. Almost all the major G7 countries, namely, the USA, UK, France, Germany, Canada, and Italy, have expressed concern. As such, in all of these countries, there is controversy among politicians, the media, and the public about who should be the provider of 5G equipment and about whether the new technology should be implemented at all. Some extreme conspiracy theory even asserts that the advent of the coronavirus crisis can be causally traced to the adoption of 5G technology. Such disputes have diminished consumers' keenness to adopt the new technology equipment. They also prompt the countries' respective governments to engage in a longer and more rigorous process of scrutiny when offering licenses to firms that attempt to sell products with new technology products.

Moreover, the falling demand and the higher entry barriers in the major large countries could also discourage firms' decisions regarding entry and sales into these countries' neighbors, thereby imposing an externality on other countries. For instance, a Japanese firm might give up on its intention to enter Denmark and Belgium if the firm failed to penetrate the French and German markets already. Such an outcome would be missed by models that do not consider firms' sequential entry decisions across countries, since without sequential entry decisions, firms' decisions to export to a new country are independent of their decisions to enter other countries.

[9]The algorithm introduced in Appendix 9.10 shows how I complete a counterfactual draw to penetrate countries during a specific period.

I therefore conduct an analogical, counterfactual analysis. In the experiment, if the large countries adopt more regulations towards mobile phone products after 2007 (when the smartphone started to boom), I ask how these responses affect mobile phone firms' entry decisions and market competition around the world over the following five years. Suppose the regulations in the USA, the UK, Canada, Germany, France, and Italy made consumers less keen to adopt the new technology equipment, that it reduced consumer demand by 30%, and that the administration scrutinizes and delays the licensing process for new products by doubling the time.

Table 15 displays the percentile change of the number of entrants and of the total import value of each Western European and North American country 1 year, 3 years, and 5 years later, after the policy was implemented in large countries in 2007. My counterfactual results show that the most remarkable percentile changes come from the countries implementing the policy themselves. The number of firms available on their markets would be decreasing by 20% to 30%, and the import value reduces around 30%.

Table 15: Externality of Trade Policy

Country	# of Firms			Import Value		
	2008	2010	2012	2008	2010	2012
USA	-29.89	-23.37	-19.64	-37.27	-33.90	-27.36
Canada	-29.66	-30.75	-30.42	-38.97	-37.79	-30.88
France	-19.06	-25.49	-22.31	-34.77	-36.94	-34.83
United Kingdom	-16.38	-24.09	-21.07	-35.85	-37.31	-33.88
Germany	-14.92	-23.81	-23.41	-36.35	-37.08	-36.00
Italy	-14.09	-23.34	-24.01	-33.93	-35.83	-36.87
Finland	-8.06	-4.76	-7.52	-2.01	-0.85	-1.38
Spain	-8.05	-5.57	-7.95	-3.40	-1.39	-2.35
Denmark	-6.49	-9.00	-5.16	-4.31	-2.48	-3.08
Portugal	-6.11	-7.05	-6.76	-2.12	-1.73	-0.92
Switzerland	-6.04	-5.77	-2.20	-3.71	-0.30	-0.28
Austria	-5.85	-7.58	-4.27	-2.36	-0.93	-3.44
Belgium	-5.29	-5.96	-1.38	-5.74	-1.68	-2.70
Netherlands	-4.90	-6.77	-4.96	-2.42	-1.67	-1.56
Ireland	-4.78	-2.72	-3.44	-2.86	-0.45	-0.93
Sweden	-3.57	-6.69	-5.38	-3.20	-3.26	-2.34
Norway	-0.18	-4.73	-4.50	-1.91	-4.00	-0.35

Entry: percentile change of number of firms on the markets. Import: percentile change of value of imported goods.

In the surrounding, smaller European countries, the number of active firms would fall by less than 10%, but the negative percentile change of import value would be within 5%. The trend of entry margin change in European countries is fascinating; when the business is blocked in the large European countries, some firms might insist on following through with their previous plan to penetrate Europe, some firms might return at a later date, and some firms might simply give up on the European market forever.

Spain is one of the large countries that does not implement the policy. The trend of entry margin change in Spain shows that some firms might stop penetrating this region in 1 year, but a portion of them will return to penetrate 3 years later. Those firms will then return and penetrate countries smaller than Spain - such as Belgium, the Netherlands, Denmark, and Portugal - five years later. At the same time, the trend of change of import value in the countries correlates with the entry margins and the size of the potential importers; the fact that the import value of almost all the surrounding smaller countries declines more in 1 year than 5 years shows that the firms that do not return even five years later are the smaller importers that contribute little to the overall import value. By contrast, the larger potential entrants apparently just delay their decision to penetrate smaller countries.

These results indicate that the higher trade barriers in large countries could discourage firms' entry margins to smaller countries as well. Nevertheless, the famous and highly productive firms would not be affected. Meanwhile, the change of entry margins over a more extended period, such as 5-year period, mainly owes to the less productive firms, which contribute relatively little to the markets.

7.1.2 Economic Geography

It has been widely documented that geography plays a significant role in shaping countries' trade flows. From the perspective of an exporter, geography and the specific fact of where the firm originated, account for which markets will be exposed to it at different expansion stages. Naturally, geographic considerations determine its growth track.

Besides the exporters' operation effectiveness, the productivity level, though, precisely how much can an exporter's "birthplace" account for its export success? The counterfactual analysis in this section aims to resolve this question. Suppose a virtual mobile phone firm has the same productivity level as Huawei and was born on Jan. 1, 2010; assign different

headquarters locations to a firm of the same productivity level and then simulate the export dynamics that flow from having a headquarters in each location.

For each headquarter location, I draw 40 simulations and take the average value. Table 16 displays the simulation results. The column representing # of Penetration indicates the number of countries the firm penetrated after 5 years. Annual global revenue shows the sum of the revenue that the firm can make in the markets it has penetrated. The Ratio is the proportion of the average annual global revenue in each specific case of the maximum case.

Table 16: Economic Geography

Headquarter	Region	# of Penetration	Annual Global Revenue	Ratio(%)
China, Mainland	China	28.25	8.11	100.00
USA	North America	20.83	4.77	58.76
Hong Kong	Hong Kong & Taiwan	26.70	4.50	55.46
Taiwan	Hong Kong & Taiwan	26.33	4.28	52.72
Japan	Japan & Korea	25.42	4.11	50.61
Korea	Japan & Korea	25.50	4.07	50.12
India	India	25.38	3.67	45.17
Singapore	Southeast Asia	26.83	3.64	44.91
Malaysia	Southeast Asia	27.00	3.64	44.84
Philippines	Southeast Asia	26.17	3.51	43.22
Thailand	Southeast Asia	26.70	3.35	41.26
Russia	Eastern Europe	23.75	3.20	39.46
United Kingdom	Western Europe	22.83	3.12	38.47
Germany	Western Europe	23.20	3.10	38.21
Indonesia	Southeast Asia	25.48	3.05	37.53
France	Western Europe	22.63	2.94	36.27
Mexico	Latin America	22.20	2.94	36.20
Spain	Western Europe	23.65	2.91	35.90
Italy	Western Europe	23.23	2.90	35.78
Australia	Pacific	23.60	2.81	34.61
Ireland	Western Europe	23.42	2.80	34.49
Ukraine	Eastern Europe	23.95	2.79	34.40
Belgium	Western Europe	23.27	2.79	34.35
Finland	Western Europe	24.88	2.77	34.18
Sweden	Western Europe	22.75	2.77	34.17
Denmark	Western Europe	23.08	2.74	33.77
Switzerland	Western Europe	23.02	2.73	33.64
Netherlands	Western Europe	21.67	2.73	33.60
Brazil	Latin America	20.17	2.72	33.55
Norway	Western Europe	23.35	2.71	33.43
Canada	North America	20.52	2.71	33.42
Austria	Western Europe	22.58	2.66	32.79
New Zealand	Pacific	23.58	2.65	32.71
Chile	Latin America	21.25	2.61	32.22
Argentina	Latin America	20.17	2.61	32.11
Colombia	Latin America	23.63	2.48	30.61
Portugal	Western Europe	22.48	2.48	30.58
Venezuela	Latin America	18.73	2.12	26.17

Note: Revenue is measured in billions of dollars

Chinese firms have the best geographical advantages in the mobile phone industry; as most of the mobile phone production chain is in China, Chinese firms will take advantage of

home production. Besides, the sunk cost to enter China is high, so Chinese firms can save (by naturally avoiding) this high entry cost. What is more, China's market size is large and provides a better platform for firms to grow. Altogether, the home production advantage, higher entry costs, and larger regional market size allow Chinese firms to rank higher in the table, and so do the other Asian countries' firms. The US firm takes the second position, on account of its large home market size and high entry protection barrier. Furthermore, the close relationships that the US enjoys with Europe and Latin America also facilitate the expansions of US firms into other regions. In the table, the high ranking of Chinese, Korean, US, and Japanese firms in the counterfactual is consistent with the real-world industry structure, namely, the fact that firms from those countries dominate the global market. As such, the table provides sound evidence that geography helps firms to solve many expansion problems as a supplement to their productivity.

If Huawei were born in Venezuela, this geography disadvantage would result in the firms' global revenue being only 26% of the average of its Chinese peers' even if this (hypothetical) Venezuelan-born Huawei still maintained the leading design and innovation skills. Compare it even with its British peer; the smaller home market size and geography disadvantage depress its sales by 33%. What is more, when one more broadly compares the European countries with the Latin American countries, it is clear that Europe's position as a geographic and economic center of global trade makes it easier for European firms to expand.

In an emerging industry, preemption is a critical and popular behavior for entrants to take an earlier mover advantage. My model provides exporters' export dynamics after their founding but it does not include the interactions between firms. If future research can also consider firms' interactions, such as preemption, in the dynamic model, this model feature would be constructive in explaining the different market structures and entrants in different countries.

7.1.3 Gains from Globalization in a Closer World

My third set of counterfactual analyses will use the global mobile phone industry as an example to study how a world with more advanced infrastructure might affect this industry's market competition and consumer surplus in each country. I then compare the results in my dynamic model with those of the purely static model.

For some historical background, in the past 5 years, the Belt and Road Initiative has completed hundreds of railway improvement projects and port construction projects to improve the physical infrastructure through land corridors and maritime roads. The infrastructure corridors, spanning some 60 countries (primarily in Asia and Europe but also including Oceania and East Africa), build a deeper connection between the East and the West and bring the world closer and closer. The infrastructure construction along these corridors significantly saves transportation costs between locations and impels more entrants to the connected countries. If this infrastructure construction halves the distance between each country pair, how will such conditions improve market competition and consumer surplus in each country?

Table 17: Gains from Globalization in a Closer World

Country/Geo	Region	Change of # of Entrants (%)			Change of Consumer Surplus (%)		
		Static	Dynamic		Static	Dynamic	
			2011	2015		2011	2015
China, Mainland	China	12.76	0.63	0.42	2.66	2.09	2.07
Japan	Japan & Korea	15.81	3.32	14.6	2.01	1.36	1.97
Korea	Japan & Korea	16.1	5.88	21.56	2.05	1.60	2.12
Russia	Eastern Europe	20.75	6.3	24.12	2.59	2.12	2.83
Ukraine	Eastern Europe	20.55	5.09	30.52	2.40	2.28	3.16
Indonesia	Southeast Asia	18.63	18.47	22.14	2.56	3.00	1.95
Malaysia	Southeast Asia	20.13	11.28	18.69	2.59	2.54	1.30
Philippines	Southeast Asia	21.41	15.1	28.15	2.87	2.87	1.80
Singapore	Southeast Asia	16.84	14.32	24.43	2.48	2.64	1.53
Thailand	Southeast Asia	20	15.41	17.82	2.49	2.95	2.36
Hong Kong	Hong Kong & Taiwan	18.83	16.31	44.64	3.30	3.12	3.87
Taiwan	Hong Kong & Taiwan	19.48	21.77	48.7	2.83	3.31	3.66
Argentina	Latin America	23.9	9.16	14.55	2.66	2.22	2.46
Brazil	Latin America	19.02	2.19	12.46	2.53	2.08	2.50
Mexico	Latin America	23.1	-2.79	10.75	2.29	2.00	2.33
Chile	Latin America	26.34	3.44	26.73	2.31	1.35	2.34
Colombia	Latin America	18.78	6.39	29.62	2.73	0.81	2.38
Venezuela	Latin America	25.74	4.67	23.27	2.44	1.14	2.15
Canada	North America	22.48	17.31	32.89	2.47	2.17	2.53
USA	North America	15.98	13.95	25.04	2.09	2.13	2.17
Australia	Pacific	18.88	0.86	18.23	2.67	1.72	2.59
New Zealand	Pacific	25.78	0.22	14.59	2.84	1.99	2.42
India	India	7.52	1.06	1.06	2.28	2.07	2.08
Austria	Western Europe	23.84	6.97	22.46	2.20	1.88	2.04
Belgium	Western Europe	18.21	5.38	22.28	2.23	1.96	2.46
Denmark	Western Europe	21.3	1.11	26.2	2.47	1.99	2.20
Finland	Western Europe	20.48	0.28	21.39	2.50	2.09	2.36
France	Western Europe	17.56	7.72	22.98	2.16	1.86	2.18
Germany	Western Europe	16.84	7.98	24.89	2.08	1.93	2.22
Ireland	Western Europe	21.45	1.93	22.94	2.46	1.96	2.46
Italy	Western Europe	15.58	9.25	23.36	2.20	1.92	2.21
Netherlands	Western Europe	16.64	7.33	28.92	2.20	2.01	2.39
Norway	Western Europe	18.96	10.9	30.47	2.38	2.15	2.28
Portugal	Western Europe	16.42	7.13	21.52	2.29	2.03	2.21
Spain	Western Europe	17.43	6.77	20.94	2.22	1.93	2.26
Sweden	Western Europe	25.96	5.3	15.62	2.61	2.05	2.31
Switzerland	Western Europe	18.98	7.54	25.74	2.11	2.03	2.32
United Kingdom	Western Europe	17.15	3.13	24.1	2.17	1.74	2.18

Suppose the distance between any pair of countries were to shorten to half of the actual distance that separated them in 2010. Based on this hypothetical, I simulate firms' entry and sales decisions over the subsequent 5 years. From the simulation's results, I then compare each country's market competition and consumer surplus in the half-distance scenario to their analogues in the real world. I use the number of entrants to measure market competition and price index to calculate consumer surplus in each country.

The dynamic model predicts a gradual increase in the number of entrants in most coun-

tries after the implementation of the project. In most countries, the increased percentile of entrants 5 years later is much higher than that of 1 year later. Compared to a static model, the dynamic model would predict a smaller increase in the number of entrants in the short run but a larger increase in the number of entrants in the long run. Additionally, the dynamic model captures the high correlation of the firm's penetration towards countries within a shared region as the change in the same region's countries is very consistent. The dynamic model can also track firms' gradual penetration towards different countries in the same region.

Except for Mexico, most countries have more entrants immediately. As Argentina's government requires all mobile phone products to be assembled in Argentina and as Brazil imposes a very high import tariff rate, I assume that firms must build local plants to enter the two countries. As a result, the more advanced delivery network would not reduce the costs of products sold in those two countries. Meanwhile, the shorter distance makes other countries more appealing than the large Latin American countries and might delay firms' decisions to export to this region, thus reducing the number of entrants in Mexico 1 year later.

Compared to the countries that are popular as assembly locations, such as China, Malaysia, Brazil, and Argentina, import-intensive countries experience a higher increase in the percentile of their number of entrants. The reason is that a shorter delivery cost benefits these countries directly, while consumers from popular assembly locations cannot benefit much, since the products that the latter consume have already been made at home; therefore, in popular assembly countries, the improvement in the delivery infrastructure does not reduce delivery costs.

In terms of raising consumer surplus of mobile phones, most of the numbers hover around 2%. Due to this industry's highly competitive property and a high estimation value of the consumer demand elasticity parameter, the change in the price margin reduces the price index and enhances consumer surplus. Consistent with the change in the number of entrants, the dynamic model would predict a smaller, increasing consumer surplus in the short term but a larger increasing consumer surplus in the long term.

8 Conclusion

My paper contributes to the literature on firms' export dynamics by developing a dynamic structural framework within which firms' decisions regarding the sequence of countries to which to export can be tractable. Most structural work on international trade previously ignored firms' sequential export decisions across countries when estimating the entry costs, or alternatively failed to build a framework in which firms' export-dynamic actions could be tractable and thereby obtain an accurate estimation of entry costs. I adopt a model in which firms sequentially choose regions' entry actions and then spread over the countries within each region. This formulation helps us to re-explore the entry costs that exporters incur and to reconcile several facts about the size and growth of individual exporters and sales of goods.

My empirical analysis of the trade policy externality reveals that the regulation of import goods' in large countries could have a significant impact on outside exporters' entry margins to the surrounding smaller countries as well. This is because firms could treat geographically close countries as complements and balance the whole region's cost and benefits when optimizing their expansion paths. The results of this work show, accordingly, that a large country's stricter regulations could influence market competition within the smaller, surrounding countries to some extent in the short run. As time goes on, firms that redirect their penetration from such a region toward alternative regions would still choose to penetrate the preferred region later, and in the long run, the losses in the smaller countries could shrink substantially.

The gains from more advanced transportation infrastructure throughout the world that were found in my model reflect a more comprehensive view of firms' penetration status towards different regions and different countries. Nevertheless, the mobile phone market is highly competitive, and the entry margins change in a closely connected world that contributes much less than the direct price and cost margin. Another available data set pertaining to another global industry with higher industry markups would help us disentangle better the entry margins and price margins of gains from globalization.

Furthermore, my model could deliver exporters' market exposure at its different expansion stages and supplement our understanding of economic geography. This model is also a

building rock for further study of how firms' interaction shapes the variation in each country's sales and market structure.

A final limitation of my paper is that I use the 40 significant countries' information instead of information for the whole world. As my study finds that decisions to enter small countries can be considered the affiliate of decisions to entry major ones, then a project involving more countries, to test the validity of my partition mechanism, would be highly desirable.

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