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Spreading the Good Apples out: Market Entry Dynamics of Quality Differentiated Products

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Spreading the Good Apples out: Market Entry Dynamics of Quality Differentiated Products

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Abstract

The paper investigates firms' rollout strategies for quality-differentiated products across geographically dispersed markets. Using a theoretical framework that integrates nonhomothetic preferences, we show that premium goods are more likely to enter wealthier markets first, allowing firms to capture higher markups. We find that the main factors influencing the selection of follow-up markets differ by product quality: for premium goods, income levels are the primary determinant of expansion paths, whereas geographic proximity is the main driver for lower-quality products. Using micro-level data from the refrigeration industry, we confirm a significant positive association between market-entry order and income for higher-quality products. Furthermore, we observe that follow-up markets tend to be geographically more dispersed for premium goods, reflecting a shift away from proximity-based expansion strategies.

JEL classification: F1, F14, F23, L68.

Keywords: market entry, gravity; nonhomothetic preferences, quality differentiated products.

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Non-technical Summary

This paper investigates how firms introduce products of differing quality into multiple international markets over time, revealing systematic links between income levels, geographic proximity, and the diffusion of innovation. The authors show that product launches are not simultaneous but follow strategic "waterfall" patterns – progressive expansions shaped by both market demand and spatial frictions. The study's central insight is that the determinants of market entry differ sharply by product quality: affluent markets attract higher-quality goods first, while lower-quality products spread primarily through geographically proximate channels.

Building on a dynamic theoretical model that combines nonhomothetic preferences with geographic constraints, the authors argue that consumer income crucially influences firms' sequencing of market entry. Wealthier markets exhibit weaker price sensitivity for premium products, enabling firms to charge higher markups that compensate for greater trade and coordination costs. Conversely, for lower-quality goods – whose demand is less income-elastic – geographic proximity and reduced entry costs dominate. This mechanism yields a dynamic form of the Alchian-Allen effect: "good apples" (high-quality varieties) progressively reach more distant, richer markets, while lower-quality goods remain concentrated nearby.

Empirical validation uses detailed micro-data from the European refrigerator industry between 2009 and 2017, a sector marked by strong vertical differentiation and standardized product attributes. A hedonic price index is constructed to measure product quality, and subsequent econometric analyses trace the order and geography of market entries across 24 countries. The findings confirm that premium models systematically debut in richer markets, while entry-level products' diffusion follows a proximity-based pattern. Conditional and rank-ordered logit estimates reveal that income exerts a significant influence on both the first market of entry and the overall rollout sequence for high-quality goods, but its effect diminishes for lower-quality ones.

Further analysis shows that for premium products, follow-up markets are geographically more dispersed, underscoring a shift away from traditional gravity-driven expansion. Counterfactual simulations suggest that a 10% rise in a country's per capita income increases the likelihood of hosting first entry of premium goods by 4.4%, corresponding to a roughly 9% higher variety of high-end models available to consumers. Consequently, wealthier regions enjoy earlier access to innovations, while poorer markets experience delayed diffusion, reinforcing cross-country disparities in product quality and technological adoption.

By integrating demand heterogeneity into a spatial trade framework, the paper extends the literature on gravity and nonhomothetic preferences, offering a dynamic explanation for how quality and income jointly shape international market expansion. The results have broad implications for understanding inequality in access to innovation, the diffusion of durable goods, and the spatial evolution of global consumer markets.

1 Introduction

Firms rarely launch new products simultaneously across all their target markets. Instead, rollouts typically follow a sequential expansion pattern –known in the marketing literature as a *waterfall entry strategy*– in which new markets are added progressively along the product life cycle.[1] These entry and expansion decisions are not random; rather, they reflect strategic trade-offs that weigh relative demand conditions against the sequencing of entry costs across locations. This paper examines how firms introduce vertically differentiated goods across dispersed markets. Such rollout patterns determine the variety of products available to consumers at any given point in time. Crucially, they also govern which markets benefit from quality upgrades earlier and become gateways through which higher-end versions spread outward, thereby shaping the dissemination of product innovations.

We establish that the relative importance of demand conditions and geographic proximity in shaping firms' entry and expansion decisions varies systematically with product quality. For premium products, firms prioritize entry into more affluent markets where they can charge higher markups, as consumer demand for high-quality goods is less price-elastic. In contrast, markups for lower-quality products are less sensitive to income variation, making geographic proximity to existing markets a more prominent driver of expansion. Our findings therefore indicate that the gravity pull of proximate markets diminishes with product quality, with income considerations dominating proximity at the top of the quality distribution. This, in turn, shapes entry and the spatial diffusion of new products, giving rise to a dynamic version of the Alchian-Allen effect, whereby premium products –the good apples– are progressively spread to more distant markets relative to their initial destinations.

Our paper combines path dependence in market-entry frictions with demand-driven forces arising from nonhomothetic preferences for vertically differentiated goods. We develop a novel multi-country dynamic framework that embeds a geography and employs the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980) as a setting

[1]See, e.g., Kalish, Mahajan and Muller (1995), Ganesh, Kumar and Subramaniam (1997), Chryssochoidis and Wong (1998), and Cho, Lee and Jeong (2023).

for introducing nonhomothetic preferences over quality. This structure accommodates flexible price elasticities that vary systematically with both consumer income and product quality. As a result, firms can charge higher markups on premium products in wealthier markets, where consumers exhibit lower price sensitivity. These enhanced margins more than offset the increased trade costs of serving more distant destinations, generating heterogeneous dynamic patterns of market expansion across goods of different quality.

Guided by the model's key predictions, we empirically examine market-entry and expansion patterns at the *product level* within the refrigerator industry. This industry is particularly suited to our analysis due to its significant vertical differentiation and high degree of uniformity of product offerings across markets. Our empirical approach uses a panel dataset of monthly sales and prices of refrigerators across 24 European countries from 2009 to 2017. The dataset enables us to trace product lifecycles within individual countries and, importantly, across the entire EU for most years. Additionally, the dataset includes detailed attributes, allowing us to construct product-specific quality indices through hedonic regressions.[2]

Leveraging the derived quality indices, we examine how per capita income shapes both the initial market-entry decisions and the subsequent sequence of market expansion for products of varying quality. To this end, we employ conditional logit regressions to study the initial market of entry and rank-ordered logit regressions to analyze the order of entry for the entire market sequence. The conditional logit estimates indicate that high-quality goods tend to enter higher-income markets first. The rank-ordered logit estimates confirm that this pattern also applies to the order of entry, and that the relation between choices of earlier market entry and high income weakens as quality decreases. These findings remain robust even after accounting for potential country-level confounders, such as population size and brand familiarity. Furthermore, by focusing on a subsample of products whose initial market entry differs from their brands' production locations, we demonstrate that these dynamic patterns are unlikely to stem solely from supply-side factors.

We next study the impact of geographic distance from the initial market of entry on subsequent market expansion decisions. Focusing on the second market(s) of entry, our findings connect with those of the extended gravity model in international trade, indicating that geographic proximity to the initial market significantly influences further

[2] As a preliminary step motivating our theoretical model, we report evidence that the fridge industry engages in *nonhomothetic* pricing-to-market: higher-quality fridges command higher markups in richer markets; conversely, markups do not vary significantly with income for fridges of lower quality. These results confirm those previously obtained by Auer, Chaney and Saure (2018) for the automobile industry.

expansions.[3] However, our analysis also reveals that the strength of this gravity effect weakens as product quality increases. Specifically, we find that higher-quality products are more likely to expand into non-contiguous markets than their lower-quality counterparts. Additionally, the average distance between the first and second markets of entry is also significantly greater for premium products.

By shaping the sequence of access to higher quality goods, firms' launch and expansion decisions influence both the timing and diffusion of product innovation. Specifically, wealthier markets tend to receive newer products earlier. Our counterfactual analysis indicates that a 10% increase in per capita income leads to a roughly 4.4% rise in the number of premium products entering these markets first. This translates into about a 9% greater variety of high-quality models offered to consumers in wealthier European markets compared to their poorer counterparts. The specific geographical context of Europe further delays the diffusion of these premium products from richer to poorer countries, which are typically surrounded by other less affluent neighbors. Consequently, wealthier markets gain earlier access, and their neighbors benefit from a geographical externality, creating disparities in the timing and reach of innovation based on both income levels and geographic proximity. These dynamic entry patterns across countries align with –and extend– Jaravel (2019) by moving from nondurables within the context of the U.S. retail sector, where higher-income households experienced a faster increase in product variety and quality, to international durable goods and market-entry sequences.[4]

In our framework, the presence of nonhomothetic preferences is pivotal to endogenously generating flexible markups, thereby weakening the impact of entry costs to more distant markets at higher-quality segments. The trade literature has long recognized that accounting for specialization patterns in vertically differentiated industries requires incorporating nonhomothetic demand schedules. Previous contributions have typically employed static models of comparative advantage, emphasizing income elasticities of demand for quality as a key driver of Linder-type (Linder, 1961) international specialization (Flam and Helpman, 1987; Murphy and Shleifer, 1997; Hallak, 2010), often resulting in home-market effects that shape trade flows (Fajgelbaum, Grossman and Helpman, 2011; Dingel, 2017; Jaimovich, Madzharova and Merella, 2023) and higher trade intensity at higher levels of quality (Hummels and Klenow, 2005; Jaimovich and

[3] E.g., Morales, Sheu, and Zahler (2019), Defever, Heid and Larch (2015), Albornoz et al. (2012).

[4] More broadly, this dynamic pattern mirrors the unequal diffusion of technologies like energy-efficient products and new pharmaceuticals, with poorer countries often lagging in access. Such disparities have significant implications for addressing challenges like climate change and healthcare outcomes (e.g., Cockburn et al., 2016).

Merella, 2015).[5] Our model, alongside the empirical analysis, focuses on the dynamic implications of nonhomotheticities for market entry and expansion along the quality dimension in the presence of geographic frictions.

Our study is concerned with the rollout of new products by incumbent exporters into familiar markets. By showing that, in the presence of nonhomothetic demand, income emerges as the predominant factor at the top-quality tiers, we complement the existing literature on extended gravity. These contributions find that *new* exporters typically expand sequentially to nearby markets to test profitability (Albornoz et al., 2012), exploit adaptation-cost savings and improved market information (Defever et al., 2015), and leverage experience in similar markets and networks of international contacts to reach more distant ones (Morales et al., 2019, Chaney, 2014). Our framework and empirical analysis reveal that for vertically differentiated goods and nonhomothetic preferences, income disparities can overturn traditional proximity-driven expansion patterns for premium products.

The paper proceeds as follows. Section 2 discusses the main dataset and constructs product-specific quality indices from hedonic regressions. Section 3 provides empirical evidence of nonhomothetic pricing-to-market in the refrigeration industry. In Section 4, we document some stylized facts regarding product market-entry sequences and their relation to income and product quality. Section 5 develops a theoretical multi-country framework that embeds variable markups and features products' market entry and expansion. Section 6 reports the results from choice models that support the theoretical predictions of faster entry of higher-quality products in richer markets. Section 7 further provides empirical evidence that geographic proximity matters less in the market expansion paths of premium goods relative to entry-level ones. Section 8 calibrates the model to the European refrigerator market and runs counterfactuals on market size and geographic agglomeration. Section 9 concludes.

2 Data and Construction of Quality Index

2.1 Scanner Data

The empirical analysis is conducted primarily with GfK GmbH's Retail Panel on Major Domestic Appliances, which is a product-level monthly frequency database comprising

[5] These results consistently indicate that trade flows are closely linked to countries' income levels, with wealthier nations showing stronger demand for higher-quality products and less affluent markets gravitating towards lower-quality products, as documented by, e.g., Schott (2004), Hallak (2006), Verhoogen (2008), Khandelwal (2010), Hallak and Schott (2011), Manova and Zhang (2012).

the unit sales and VAT-inclusive scanner prices of different types of white goods.[6] As we are interested in products characterized by a high degree of vertical differentiation, we focus on refrigerators, as they exhibit the widest price distribution in the data. The panel covers 22 current EU members plus the UK and Serbia from January 2009 until September 2013 and extends to January 2017 for a subset of eight countries.[7] In addition to prices and monthly quantities, the data contains a number of product characteristics such as brand, energy label, and others summarized in Table C.2 in Appendix C.[8]

Forty-two different brands are present in the data. Nineteen of them account for 90% of all observations and, with few exceptions, the top brands are present in all 24 markets. Identical products share the same unique identifier across countries. We can thus observe both the country-specific and (at least until 2013) nearly all EU-wide sales of a given product, as well as its contemporaneous prices across its various sales destinations. On average, the dataset records information on 5,421 unique refrigerator models annually and a total of 11,529 products throughout the duration of the panel. These products account for about 74.4% of the EU's aggregate expenditure on refrigerators between 2009-2013.[9]

2.2 Product-Specific Quality Index

To segment the product space by quality, we construct a time-invariant product-specific quality index using a hedonic log-linear regression relating the prices of goods to a set of

[6]These include refrigerators, washing machines, dishwashers, and other household appliances. Unit sales are the total units sold of a product across all brick-and-mortar retailers in a given country on a given month-year combination, whereas scanner prices are the unit sales-weighted mean prices across these retailers over the same period. We do not observe retailer-specific sales or prices within a country. Sales by online retailers are not part of the database. Throughout the analysis, we will refer to a unique product (e.g., Bosch KAG93AIEP) interchangeably as a 'product', 'model', or 'variety'.

[7]See Table C.1 in Appendix C for detailed time coverage by country. The UK was still part of the EU during the years covered by the dataset. The five EU markets not included in the data are Bulgaria, Cyprus, Ireland, Luxembourg, and Malta.

[8]The coverage of refrigerators' characteristics is also relatively more comprehensive than that of other types of products in the data (see Table C.2). These appliances are also more diverse in capacity and dimensions, energy efficiency, functionality and settings, and other important attributes.

[9]This share drops from 2014 onward due to the fall in country coverage. For 2009-2013, the average share was estimated on the basis of yearly aggregate apparent consumption, defined as the value of production plus imports net of exports in the Prodcom database as reported in Table 7 in European Commission (2016). The relevant categories are 27511110 - Combined refrigerators-freezers, with separate external doors, 27511133 - Household-type refrigerators (incl. compression-type, electrical absorption-type) (excl. built-in) and 27511135 - Compression-type built-in refrigerators.

TABLE 1. Descriptive Statistics

	All		By quality quartile							
			(1)		(2)		(3)		(4)	
	Mean	Mdn	Mean	Mdn	Mean	Mdn	Mean	Mdn	Mean	Mdn
Price	684.2	544	357	329	517	473	703	641	1,213	1060
	(493.7)		(128.3)		(194.5)		(291.1)		(676.7)	
N	912,951		238,651		236,309		223,187		214,804	
Units	35.7		49.0		37.3		31.3		24.0	
	(111.1)		(149.9)		(107.7)		(93.3)		(75.1)	
N	1,026,132		263,219		265,878		251,152		245,883	
Qlty	0.148		-0.375		-0.020		0.283		0.777	
	(0.454)		(0.153)		(0.091)		(0.090)		(0.269)	
N	9,817		2,564		2,634		2,267		2,352	

Notes: The table shows descriptive statistics per product per date per country for a subsample that excludes the 1,250 products (about 15,000 observations) in the data sold in only one market throughout their life cycle. Observations with prices that were zero or negative, or with negative sales, have been discarded. 'Quality' is the product-specific quality index constructed from the hedonic specification (2). Columns (1)-(4) report statistics for four quantiles of the quality index. 'Mdn' stands for median value. All prices are in Euro. Table C.4 in Appendix C reports identical statistics for the full sample including single-sale-destination products.

observed essential attributes. In particular, we use the specification:

$$\ln \text{Price}_{jmd} = \sum_{a=1}^{4} b_a \kappa_{aj} + \lambda_{md} + u_{jmd}, \tag{1}$$

where $\ln \text{Price}_{jmd}$ is the logarithm of the price of product j in country/market m on date (month-year) d and κ_{aj} is attribute a, which is product-specific. We consider four separate attributes coded as categorical variables; namely, number of doors and freezer position, availability of no-frost function, energy label, and brand (see Table C.2).[10] Since there are multiple price observations for each product over countries and time, we explicitly control for country-by-date fixed effects λ_{md}. These indicators capture any country-specific time-varying confounders that may affect average prices of fridges in a given country on a given date, as well as nest country dummies and EU-wide time-varying confounders.

We compute product-specific quality indices using the estimated coefficients on each characteristic's marginal contribution to the product's market price, purposefully omitting

[10] In particular, high energy and cooling efficiency as captured by the energy label are closely associated with higher quality due to requirements of advanced compressor-technology.

country-date and idiosyncratic variation; namely:

$$\hat{q}_j = \sum_{a=1}^{4} \hat{b}_a \kappa_{aj}. \tag{2}$$

The point estimates from eq. (1) are reported in Table B.1 in Appendix B. More energy-efficient appliances, fridges featuring multiple doors, as well as the presence of a no-frost system, are associated with higher prices. In addition, well-known high-end brands (such as Gaggenau and Miele) tend to exhibit a significant price premium.[11] Figure C.1 in Appendix C displays a histogram with the quality index, pointing to a substantial degree of vertical differentiation in the sector.[12]

As our analysis studies the pricing and entry dynamics of the same product across multiple destinations, we focus henceforth solely on multi-market appliances. These models constitute 90% of the sample. The descriptive statistics for all products and by quality quartiles are reported in Table 1 after removing single-sales-destination devices. Average sales are about 35 units per month per country at a mean price of 682 euro. Not surprisingly, segmenting the product space by quality translates into clear price and unit sales separation: premium quality products (those in the top quality quartile) are nearly four times more expensive and sell roughly half the volume of entry-level products (bottom quality quartile). Given the limited prevalence of single-country appliances, the sample in Table 1 remains similar in terms of characteristics to the complete sample summarized in Table C.4 in Appendix C.

Figure 1 plots the relation between the shares of high-quality and low-quality products over the total number of products offered in a country and its income per head. The figure reveals a distinct pattern of quality differentiation in consumption linked to income levels. Specifically, panel (a) shows that as income increases, the share of entry-level products declines. In contrast, panel (b) shows a positive correlation, indicating that the proportion of top quality products increases with higher income levels.

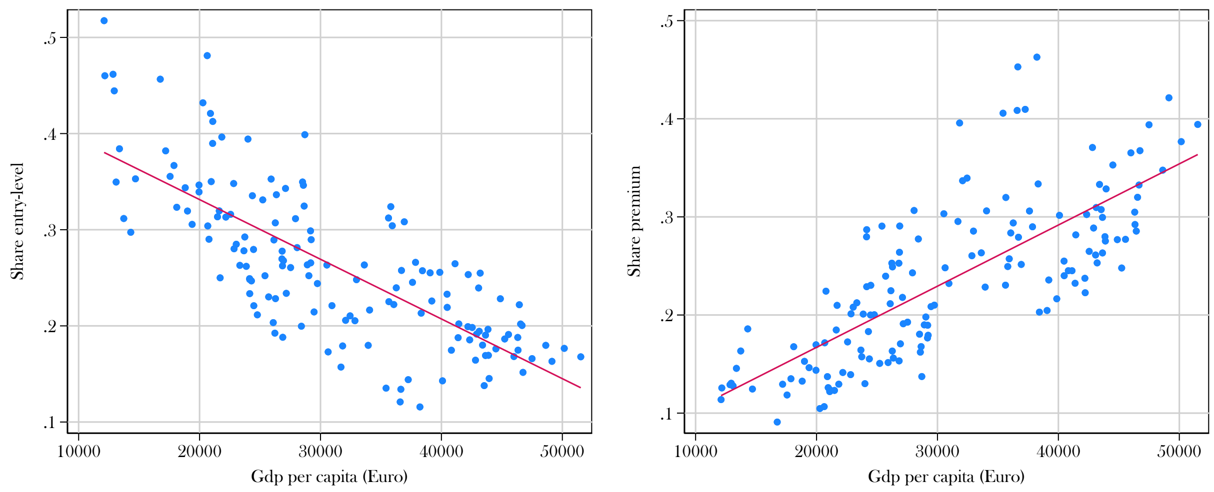
3 Pricing-to-Market along the Quality Dimension

The trade literature has repeatedly acknowledged that nonhomothetic preferences, especially in relation to quality, may imply that richer households display lower price

[11] Brand names are not explicitly reported in Table B.1 but are available from the authors upon request.

[12] The index ranges from -1.05 (a refrigerator model of brand PKM with an average price over its life cycle of 254 Euro) to 2.31 (a refrigerator model of brand Gaggenau with an average price over its life cycle of 6,421 Euro).

FIGURE 1. Premium and Entry-level Product-shares by Income per Capita



(a) Entry-level (b) Premium

Notes: The figure plots country-specific yearly shares of entry-level products (number of entry-level products over the total number of products per year) in (a) and of premium products (number of premium-quality products over the total number of products per year) in (b) vis-a-vis GDP per capita. Entry-level products are those in quartile one, and premium products in quartile four of the product-specific quality estimates obtained from eq. (2). The lines in both graphs are linear prediction plots. Figure C.2 in Appendix C shows that the same relationships hold with respect to the shares of unit sales from total sales for entry-level and premium products.

elasticities for higher-quality varieties. If this is indeed the case, markups charged on higher-quality models would turn out to be relatively higher in richer markets.[13] Next, we provide evidence that quality-pricing-to-market is present in the cold-appliances sector. Specifically, we employ the following regression equation:

$$\ln \text{Price}_{jmd} = \alpha_{jd} + \delta_{jm} + \beta_1 \cdot \ln \text{Income}_{md(t)} + \beta_2 \cdot (\ln \text{Income}_{md(t)} \times \hat{q}_j) + \epsilon_{jmd}, \quad (3)$$

where $\ln \text{Income}_{md(t)}$ is the log of per capita income in country m in year t and $\hat{q}_j$ is the product-specific estimate of quality as per eq. (2). A positive β_2, the coefficient on the interaction term between per capita income and the quality index would be indicative of higher-quality goods commanding relatively higher markups in richer markets. The inclusion of product-date specific fixed effects α_{jd} ensures that price comparisons across countries occur within the same appliance j and date d, and thus that any time-varying product-specific shocks common to all markets (such as aging over the life cycle or

[13] Simonovska (2015), for example, finds that for identical items supplied by a large and global clothing retailer, a substantial fraction of cross-country price variation is driven by pricing-to-market. Auer et al. (2018) have found evidence of quality pricing-to-market depending on income in the automobile industry.

variation in the cost of model-specific inputs) are taken into account. Note that α_{jd} further subsume brand indicators and also control for all other permanent product attributes.

Variations in the prices of products across destinations at a given date may also reflect certain country-specific costs. In particular, since each product destined for a specific market is usually manufactured in a single location, part of the cross-country price variation for identical goods will arise from differences in transportation and handling costs. Furthermore, because the data include sales in brick-and-mortar stores, price differences will also result from destination-specific rents, local wages, and distribution costs. To disentangle the effect of discretionary markups from those of the above costs, we rely on additional controls: eq. (3) includes product-by-country fixed effects δ_{jm}, which will capture the impact of factors such as varying shipping costs, as well as absorb country dummies, and thus average differences in labor, rental, and other operational costs across countries. Furthermore, in our most demanding specification, we incorporate country-by-date fixed effects (θ_{md}), which control not only for the levels of any country-specific confounders but also for any changes in these over time.

Table 2 reports the results of the estimation of eq. (3). Column (1) exploits the cross-country variation in prices within the same product within the same date, yielding a statistically significant price elasticity with respect to income per head of 0.25%. However, this estimate ceases to be significant once product-by-country indicators enter the specification in Column (2). Note that if products sold in a specific destination market are manufactured in one single location throughout its life cycle, these fixed effects will tend to absorb the impact on final prices paid by consumers of product-specific across-destination variation in transport costs. They will also absorb any non-time-varying differences between countries such as geographical features, alongside long-standing disparities in consumer preferences, infrastructure, taxation, etc.

Specifications (3)-(7) include our main coefficient of interest: an interaction term between the quality estimate and log GDP per capita to capture heterogeneity in pricing-to-market. The sign and significance of the interaction term suggest that the impact of per capita income on markups is increasing in product quality. In terms of its quantitative impact, the estimate of β_2 in (3) indicates that relative to a product of median quality ($q = 0.118$), the effect of income on a product in the 90th percentile of quality is a 0.120 higher log-price ($(0.799 - 0.118) * 0.177$).

In columns (4)-(7) we sequentially add a set of additional covariates. Specifically, based on the GfK data, we calculate brand-specific market shares (MS Brand) as the ratio of a brand's unit sales in a given country on a given date to its total sales within the same country-date pair. We also use these shares to construct a Herfindahl-Hirschman index (HHI) of market concentration for each country-date. We further supplement the GfK

TABLE 2. Pricing-to-market: Income and Quality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln Income	0.251***	-0.021	-0.042	-0.061	-0.060	-0.059	
	(0.052)	(0.060)	(0.063)	(0.070)	(0.071)	(0.071)	
ln Income$\times\hat{q}_j$			0.177**	0.191***	0.191***	0.184**	0.192***
			(0.065)	(0.067)	(0.067)	(0.068)	(0.047)
ln Pop				-0.232	-0.230	-0.238	
				(0.377)	(0.372)	(0.370)	
ln MS Brand				-0.006***	-0.006***		
				(0.002)	(0.002)		
ln Retail				0.009	0.009	0.009	
				(0.020)	(0.020)	(0.020)	
ln Energy				0.060	0.060	0.061	
				(0.043)	(0.043)	(0.043)	
HHI					-0.018	-0.026	
					(0.128)	(0.118)	
HHI$\times\hat{q}_j$						0.189*	-0.005
						(0.109)	(0.070)
δ_{jm}		Yes	Yes	Yes	Yes	Yes	Yes
θ_{md}							Yes
N	785,232	778,341	778,341	778,341	778,341	778,341	778,341

Notes: The table shows results from the estimation of eq. (3). All specifications include product-by-date fixed effects, not reported. Specifications (2)-(7) control for product-by-country indicators, while (7) further incorporates country-by-date fixed effects. Ln Pop, ln Retail, ln MS Brand, and ln Energy are the logarithms of population, retail turnover index, brand market share, and bi-annual household energy prices. HHI is the Herfindahl-Hirschman index of market concentration. See Table C.3 for a detailed description of these variables and summary statistics. Standard errors are robust, and two-way clustered by product and by country throughout. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

data with a set of country-specific variables at date, bi-annual, or yearly frequency, namely population, index of retail turnover, energy prices, and others. (All these variables are defined and summarized in Table C.3.)

Column (4) adds (log) population to control for market size, country-date specific brand market shares, and retail index to capture any underlying brand and retail expenditure evolution over time. It also includes bi-annual household energy prices as in economies with relatively costly energy, better quality refrigerators may be purchased due to their higher energy efficiency. Amongst these additional covariates, only the brand market share is found to be significantly associated with prices, specifically a 1% share increase (brand familiarity) is found to reduce prices by about 0.01%. The point estimate of the interaction term increases to 0.191, remaining highly significant. In (5)-(6) we additionally control for market concentration through the HHI and its interaction with the quality estimates. Estimates and significance of β_2 in (5) and (6) remain virtually unaffected. Interestingly, the specification in (6) also suggests that higher-quality products are also more expensive in less competitive markets.[14]

Lastly, in column (7) we add a full set of country-date fixed effects. These fixed effects nest all previous controls except for the interaction terms. Remarkably, the point estimate of β_2 remains essentially intact, and so does its level of statistical significance. That is, even when controlling for all time-varying factors within each country, higher-quality refrigerator models are found to command relatively higher prices when sold to consumers in richer markets. Given the inclusion of extensive sets of fixed effects, effectively absorbing different sources of price variability across destinations and time, we interpret the results in columns (3)-(7) as robust evidence of variable markups along the quality dimension.

4 Market Entry and Quality

Section 3 shows supporting evidence for the presence of nonhomothetic preferences along the quality distribution enabling firms to engage in pricing-to-market. In this section, we explore a series of qualitative dynamic patterns in terms of the market entry order of products belonging to different quality layers.

Within each month-year combination (date), each market comprises various cohorts of products launched at different dates.[15] We differentiate between two types of entry dates per product: a country-specific (local) and an EU-wide (global) date. Let y_{jmd} be the unit sales of product j in country m on date d. The country-specific date of entry of j in m is given by: $\widetilde{d}_{jm} = \min\{d|y_{jmd} > 0\}$. In other words, we consider the country-specific date of entry in a given market to be the first date when the sales of j in this market are positive. The minimum of the set of all of j's country-specific entry dates, $\widetilde{d}_j = \min\{\widetilde{d}_{jm}, \widetilde{d}_{jm'}, ..., \widetilde{d}_{jz}\}$, yields the EU-wide entry date of product j. The ordered sequence of country-specific entry dates $\{\widetilde{d}_{jm} \leq \widetilde{d}_{jm'} \leq, ..., \leq \widetilde{d}_{jz}\}$ maps directly into product j's destination entry sequence, with country m being the first market of entry, country m' the second market of entry (provided that strict inequality applies), and so on.

Correctly identifying the timing and location of EU entry requires full country coverage and the ability to trace a product from the start of its life cycle. Because our data cover

[14]The estimate of the coefficient associated with this interaction term loses significance, however, once we control for country-date fixed effects in specification (7).

[15]Henceforth, by 'cohort' we will designate a group of products entering a given market on the same *date*, and by 'annual-cohort' all (maximum twelve) cohorts launched in the same *year*.

2009-2017, we can observe sales of products introduced before 2009, but their market sequences cannot be fully reconstructed. Similarly, when country coverage shrinks in 2014, we face the same problem for new entrants: both their first market and overall sequence become uncertain.[16] To address this, our analysis is now restricted to products with global first dates between 2009 and 2013, tracking their sales (if any) through 2017. This restriction cannot fully prevent incomplete sequences in later years, but it ensures that each product's first EU market is correctly observed.[17]

Table 3 splits countries by the year-specific median GDP per capita and reports product characteristics for those sold: (i) only in above-median countries, (ii) only in below-median countries, and (iii) in both groups over their life cycles. Products sold exclusively in a single country throughout their life cycles are excluded (since these are likely to serve localized, retailer-specific markets). Among the remaining sample, 29% of the products appear only in richer markets, 14% only in poorer markets, and the rest in a mixture of both. A clear pattern of quality and price segmentation also emerges: the mean quality of products sold exclusively in richer destinations is substantially higher than those confined to poorer economies, as already indicated in Figure 1. The same pattern repeats within the group of products marketed in a mixture of higher and lower income locations: quality (and average prices) decrease with the share of below-median income destinations in which these appliances are present.

We next turn to analyzing products' destination-entry patterns. Is the order of market entry associated with income and does this pattern vary with quality? Figure 2 displays the average income per head by order of market entry for all products (Plot (a)) and for those in Panel C of Table 3 (Plot (b)). The plots show that market order is negatively correlated with income, with first (earlier) destinations generally associated with higher per capita incomes than follow-up markets. Interestingly, this relationship is particularly pronounced for models in the top quartile (premium products), while it appears rather weak (or barely existent) for those in the bottom quartile (entry-level products). Figure C.3 in Appendix C replicates Figure 2 using only products sold in at least five destinations over their life cycle, suggesting that the dynamic patterns shown in Figure 2 do not seem to be driven by selection with different product composition per market order.

[16] See Plot (a) of Figure C.6 in Appendix C, which visualizes aggregate sales per annual cohort. Sales for the 2008 cohort are truncated, whereas cohorts from 2014 onward (not shown) omit markets. In both cases, the first EU market of entry cannot be identified.

[17] Given an average EU life cycle of 4-5 years, country sequences are nearly exhaustive for the 2009-2010 cohorts and least complete for the 2013 cohort, whose second markets may be misidentified once coverage drops to eight markets in 2014. Section C.1 details methods for estimating product life cycles within and across EU markets. The distribution of the country-specific first dates is depicted in Figure C.7 in the Appendix.

TABLE 3. Market Segmentation by Income

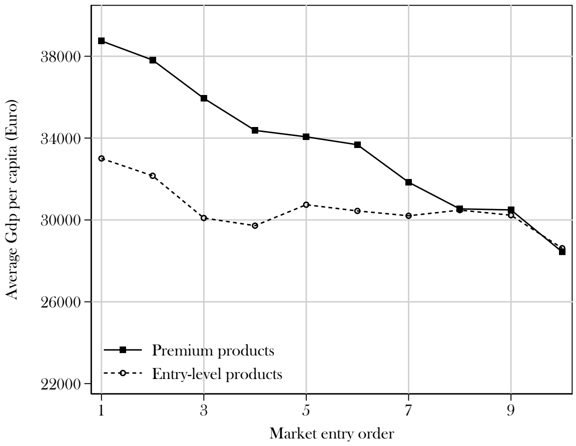
	Products sold throughout life cycle in countries with incomes						
	A. Above median	B. Below median	C. Both				
				of which mean share below-median			
				0.1	0.4	0.6	0.9
Quality	0.144	-0.034	0.219	0.345	0.257	0.148	0.042
	(0.466)	(0.386)	(0.446)	(0.472)	(0.429)	(0.423)	(0.363)
Price (Euro)	634.0	438.5	659.2	821.2	701.6	659.4	526.2
	(454.2)	(274.7)	(517.4)	(608.2)	(441.6)	(579.7)	(375.2)
Units sold	42.4	32.1	36.7	34.5	36.2	40.6	38.6
	(103.0)	(97.4)	(112.1)	(119.7)	(111.8)	(124.7)	(102.6)
Life cycle (months)	40.2	41.9	55.2	54.7	55.4	55.7	55.5
	(21.0)	(17.5)	(16.4)	(16.5)	(17.3)	(16.5)	(15.3)
No. of products	1,880	832	2,500	872	600	465	563

Notes: The table provides descriptive statistics on the quality index, prices (in Euro), and units sales for products sold in: only above-median income countries, only below-median income countries, or a mixture of both. Median income is year-specific. Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Sweden and the UK are always classified as above-median income countries; Croatia, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia are always classified as below-median income countries; Spain is above-median in some years, and classified as below-median in others. The sample excludes products sold in only one country and is based on annual cohorts 2009-2013 whose sales can be observed until 2017. The last four columns report statistics by quantiles of the share of below-median-income countries in the total number of countries where they are sold. Thus, quantile one has a 10% mean share of below-median-income countries, while the analogous for quantile four is 90% on average. The life cycle is the time length (in months) between a product's last and first date present in the panel.

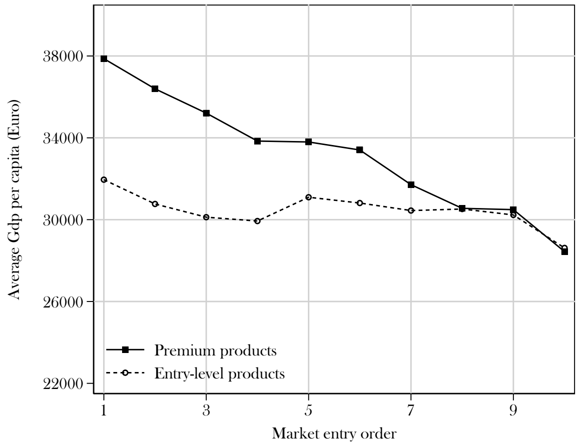
If income is a stronger predictor of (early) market entry for high-quality products than for low-quality ones, then geographic proximity between sequential markets should play a relatively smaller role for the former. Preliminary evidence supporting this idea is presented in Figure 3. This figure plots the average distance in km of products' follow-up markets relative to their initial markets of entry for premium products (solid line) and entry-level products (dashed line). Two patterns stand out. First, proximity matters regardless of quality: markets nearer the first destinations are entered earlier in the life cycle than more remote ones. Second, premium products tend to be rolled out in markets that are more distant from their initial markets of entry than entry-level products.

The stylized facts regarding the initial markets of entry in Figures 2 and 3 can arguably reflect a home market effect, in which high-quality products are produced disproportionately in higher-income countries, which are also more likely to serve as their first markets of sale. Likewise, distance may matter less to them simply because such products are manufactured closer to a wealthier customer base. In Appendix C.2

FIGURE 2. Order of Market Entry vis-a-vis Income



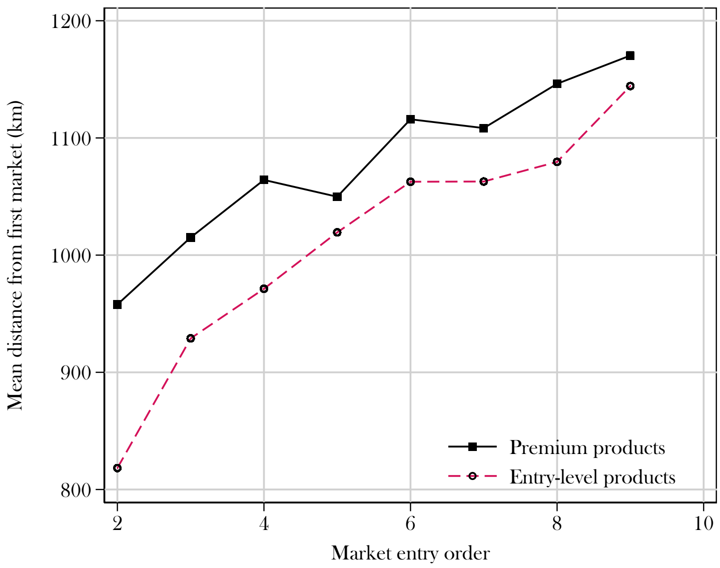
(a) all products



(b) products sold in above- and below -median income countries

Notes: Plot (a) depicts average income per capita by all products' order of market entry (first, second, third, etc. market) and quality (premium products (quartile four) shown as solid line, and entry-level products (quartile one) – as dashed line) for all products. Plot (b) visualizes the same relationship but only for products sold both in above-median and below-median income countries. The order of market entry is determined as per Table C.5. Quality quartiles are based on the full set of products.

FIGURE 3. Distance of further markets relative to first destination of entry



Notes: The figure plots the average distance (in km) of products' sequential markets of entry (second, third, etc. markets) relative to their first destination market differentiating between premium and entry-level products. Bilateral distances between countries are retrieved from the CEPII data set, using intra-country agglomeration weighted measures.

(see Table C.6), we examine the European manufacturing locations of refrigerators of the 41 brands in our sample over the period 2009–2013. This analysis shows that for roughly 65% of the products in our sample, the first sale destination was actually an export market (i.e., the initial market of entry did not coincide with the manufacturing location). This evidence will be leveraged in Sections 6 and 7 to conduct robustness analyses on subsamples of products whose initial markets of entry differ from their countries of production.

5 A Model with Variable Markups and Gravity

This section introduces a tractable model with nonhomothetic preferences along the quality dimension building on the Almost Ideal Demand System proposed by Deaton and Muellbauer (1980). The framework generates demand functions with variable price elasticities linked to income elasticities, leading firms to optimally adjust markups based on consumers' incomes. The first subsection analyzes this mechanism within a static single-country setup. We then extend the framework to a dynamic multi-country model, where proximity to previously served markets facilitates market expansions.[18]

5.1 Static model in a single country

We consider an economy with a continuum of households with mass H. Each household has the same nominal income Y. There is a continuum of varieties of a differentiated good with mass N. Household preferences are summarized by the indirect utility function:

$$\ln \left(\frac{Y}{a(\mathbf{p})} \right)^{\frac{1}{b(\mathbf{p})}},$$

where $a(\mathbf{p})$ and $b(\mathbf{p})$ are price aggregators given by:

$$a(\mathbf{p}) \equiv \exp \left(\int_{\mathcal{J}} \alpha_j \ln p_j \, dj + \frac{1}{2} \int_{\mathcal{J}} \left[\gamma_{jj} (\ln p_j)^2 + \int_{k \neq j} \gamma_{jk} \ln p_j \ln p_k \, dk \right] dj \right),$$
$$b(\mathbf{p}) \equiv \exp \left(\int_{\mathcal{J}} \beta_j \ln p_j \, dj \right),$$

[18] The AIDS structure has been recently used by Fajgelbaum and Khandelwal (2016) to model nonhomothetic demand and capture its implications on gains from trade across consumers with different incomes. Unlike our study, theirs does not consider quality differentiation. To our knowledge, this is the first paper in the trade literature to rely on the AIDS structure to account for nonhomotheticities along the vertical dimension.

where $j, k \in \mathcal{J}$ index varieties. As shown by Deaton and Muellbauer (1980), to adhere to consumer rationality, $a(\mathbf{p})$ and $b(\mathbf{p})$ must satisfy the following restrictions:

$$i) \int_{\mathcal{J}} \alpha_j \, dj = 1, \; \alpha_j > 0; \quad ii) \int_{\mathcal{J}} \beta_j \, dj = 0; \quad iii) \, \gamma_{jj} + \int_{k \neq j} \gamma_{jk} \, dk = 0, \; \gamma_{jk} = \gamma_{kj}. \tag{4}$$

We let henceforth $\Upsilon \equiv H \times Y$ denote the level of nominal GDP in the economy. Using Roy's identity, we can derive the market demand for variety j, which (provided that it is strictly positive) will be given by:

$$D_j = \left(\alpha_j + \gamma_{jj} \ln p_j + \int_{k \neq j} \gamma_{jk} \ln p_k \, dk + \beta_j \ln \left(\frac{Y}{a(\mathbf{p})} \right) \right) \frac{\Upsilon}{p_j}. \tag{5}$$

Following Deaton and Muellbauer (1980) $a(\mathbf{p})$ can be interpreted as a price index at the subsistence level.[19] We can thus define real income as:

$$y \equiv \frac{Y}{a(\mathbf{p})}.$$

We let $y \geq 1$ always hold, meaning that households' incomes lie above the subsistence level. In this context, β_j will govern the income elasticity of demand for variety j. Varieties whose $\beta_j > 0$ exhibit an income elasticity above one and will thus account for larger expenditure shares in richer households. Varieties with $\beta_j < 0$ will instead display income elasticity below one, and households' expenditure shares in those varieties decline with y.

Each variety j is characterized by a level of quality q_j. For simplicity, we assume that there are only two levels of quality, $q = l, h$, with $l < h$, and let N_q be the mass of the set $\mathcal{J}_q$ of varieties of quality q, with $N_l + N_h = N$. The trade literature has consistently shown empirically that higher-quality varieties are associated with greater income elasticity of demand (e.g., Hallak, 2006; Verhoogen, 2008; Khandelwal, 2010). Accordingly, we let the parameter governing the income elasticity of variety j (β_j) be positively tied to its level of quality relative to the average level of quality in the market.

Assumption 1 (nonhomotheticities). *Let* $\Gamma \equiv (N_l l + N_h h) / N$. *Then:*

$$\beta_j = q_j - \Gamma. \tag{6}$$

Assumption 1 implies that varieties whose quality is greater than the average quality in the market ($q_j > \Gamma$) have an income elasticity above one (hence, they are luxuries).

[19] $a(\mathbf{p})$ becomes in fact the exact price index at any income level when $\beta_j = 0$ for all j.

Varieties with $q_j < \Gamma$ conversely display income elasticity below one.[20] Without any loss of generality, we will henceforth let $l > 0$ and $h - l = 1$.

Next, we impose some additional structure on the demand functions in (5) in terms of the patterns of cross-substitution of demand between varieties.

Assumption 2 (cross-substitution). *Let $j \in \mathcal{J}_q$ and $k \in \mathcal{J}_{q'}$, with $q, q' = l, h$. Then:*

$$i)\ \gamma_{jk} = \frac{1}{N_q}, \ \text{for all } k \neq j \text{ such that } q' = q;$$

$$ii)\ \gamma_{jk} = 0, \ \text{for all } k \neq j \text{ such that } q' \neq q.$$

Assumption 2.i entails that the degree of cross-substitution across all pairs of varieties within the same quality level is strictly positive and inversely related to the total mass of these varieties present in the market. Assumption 2.ii precludes cross-substitution across varieties belonging to different layers of quality.[21]

To comply with the parametric restrictions (i) and (iii) in (4), we lastly impose a specific structure on α_j and on γ_{jj}. For the former, we will henceforth assume that $\alpha_j = 1/N$ for all $j \in \mathcal{J}$. With regards to γ_{jj}, Assumption 2 entails that $\gamma_{jj} = -\int_{k \in \mathcal{J}_q, k \neq j} N_q^{-1} dk$ must hold for any variety $j \in \mathcal{J}_q$. This, in turn, boils down to $\gamma_{jj} = -1$ for every variety j regardless of its quality level.

Assumption 2 coupled with the parametric restrictions in (4) allows us to obtain the following expression for the price elasticity of D_j:

$$\varepsilon_j \equiv -\frac{\partial \ln D_j}{\partial \ln p_j} = 1 + \frac{1}{-\ln p_j + (q_j - \Gamma)\ln y + \dfrac{1}{N} + \dfrac{1}{N_q}\displaystyle\int_{k \neq j} \ln p_k \, dk}. \tag{7}$$

Note that $D_j > 0$ implicitly entails $\varepsilon_j > 1$.[22] In the optimum, the producer of variety j will thus set $p_j = [\varepsilon_j/(\varepsilon_j - 1)]c_j$, where c_j denotes the marginal cost j.[23]

[20] Note that Assumption 1 ensures that condition $\int_{\mathcal{J}} \beta_j \, dj = 0$ in (4) will always be satisfied in our model.

[21] In conjunction with Assumption 2.i, fixing cross-substitution between varieties belonging to different quality layers at zero through Assumption 2.ii is an extreme way to model the notion that consumers are more likely to substitute between similar rather than markedly different levels of quality. The assumption can be relaxed at the cost of more complicated algebra.

[22] Note that the continuum of varieties implies that a change in the price of a single variety has measure-zero weight on the cost-of-living index $a(\mathbf{p})$, and therefore real income remains unaltered by the change in p_j while holding the prices of all the other varieties constant.

[23] Recall that $p_j = [\varepsilon_j / (\varepsilon_j - 1)]\, c_j$ is the standard markup over the marginal cost that obtains from solving the optimization problem: $\max_{p_j} \Pi_j = (p_j - c_j) \times D_j(p_j)$, where $\varepsilon_j \equiv -(\partial D_j/\partial p_j) \times (D_j/p_j)$.

We let henceforth $\mu_j \equiv \varepsilon_j / (\varepsilon_j - 1)$ denote the markup charged by firm j. Thus, firms optimally set $p_j = \mu_j c_j$. We assume that the marginal cost of production is constant and identical for all varieties in the same quality layer, that is, $c_j = c_q$ for all $j \in \mathcal{J}_q$. From (7), it then follows that:

$$\mu_j + \ln \mu_j = 1 + (q_j - \Gamma) \ln y + \frac{1}{N} + \frac{1}{N_q} \int_{k \neq j} \ln \mu_{k_q} \, dk. \tag{8}$$

Equilibrium markups

The previous analysis has focused on the optimal behavior of a generic firm j in isolation, taking the behavior of other firms in the market as given. In equilibrium, each firm will behave optimally given the behavior of their competitors. The strategy of each firm j consists of choosing the optimal markup μ_j^* given the markups chosen by all other firms $\{\mu_k\}_{k \neq j}$.

Equation (8) determines the optimal markup charged by firm j producing a variety of quality q given the markups charged by all other firms producing varieties of the same quality level. Those firms will also optimally choose their markups following an expression analogous to that in (8). The Nash equilibrium will therefore be characterized by a full set of conditions like (8) holding simultaneously for all firms. The lemma 2 in Appendix D shows that there is a unique Nash equilibrium and that this equilibrium will necessarily be symmetric, in the sense that μ_j^* will be identical for all for all $j \in \mathcal{J}_q$.

Denote henceforth by μ_q^* the equilibrium markups charged on varieties of quality $q = l, h$. The following proposition demonstrates that markups behave heterogeneously across different quality and income levels:

Proposition 1. *Given the mass N_q of varieties of quality $q = l, h$, where $N_l + N_h = N$, the equilibrium markups are given by:*

$$\mu_l^* = 1 + \frac{1}{N} - \frac{N_h}{N} \ln y, \tag{9}$$

$$\mu_h^* = 1 + \frac{1}{N} + \frac{N_l}{N} \ln y. \tag{10}$$

The main implication of Proposition 1 is that markups vary heterogeneously with the level of income y: markups charged on higher-quality varieties are increasing in y, whereas the opposite holds for low-quality varieties.[24] This result stems from the interplay

[24] To be perfectly rigorous, μ_h^* varies with y provided that $0 < N_q < N$. This is indeed the case, as according to Assumption 1 the income elasticity of demand depends on the quality of a variety relative to the average quality in the market. As a result, when $N_q = N$ for some q, all varieties actively offered on the market are of equal quality, and demand elasticity is one for all of them.

between Assumption 1 and the fact that, within the AIDS structure, higher income elasticities translate into weaker price elasticity of demand via the term $(q - \Gamma)\ln y$ in (7). Assumption 1 ties income elasticities to the levels of quality of each variety. In turn, as is clear from (7), the presence of the term $(q - \Gamma)\ln y$ means that income-elastic varieties tend to display lower price elasticity as real incomes grow. Consequently, higher-quality varieties will end up exhibiting lower price elasticity in richer markets, thereby allowing firms to charge higher markups in those markets.

Lastly, we can compute the equilibrium profit (π_j) earned by the producer of variety j. Since $\pi_j = (p_j - c_j)\,D_j$, using (5) and (7) together with $\mu_j = \varepsilon_j/(\varepsilon_j - 1)$, we can obtain:

$$\pi_j = \frac{(\mu_j - 1)^2}{\mu_j}\Upsilon. \tag{11}$$

Notice from (11) that $\mu_j > 1$ implies that $\partial\pi_j/\partial\mu_j > 0$. Based on (9) and (10), it follows that holding the value of Υ constant, producers of high-quality varieties (resp. low-quality varieties) will tend to earn higher profits in richer markets (resp. poorer markets).

5.2 A multiple-country dynamic framework: Market entry and expansion

This subsection extends the single-market static framework to a dynamic setup with multiple markets. The goal is to allow entry of newly designed varieties and study how their dynamics in terms of first market entry and subsequent expansions to additional markets vary with the quality of incoming varieties.

We assume that there is an even number $M > 4$ of countries/markets in the world economy ($\mathcal{W}$), indexed by $m \in \mathcal{W}$. Half of the countries host low-income households and the other half host high-income households. We assume that the level of household income in the poorer markets is $y_p = 1$, whereas that of richer households is $y_r > 1$. Since the main intention of the model is to focus on the impact of real income differences on markups and entry dynamics, we deliberately shut down any variation of aggregate market size across countries. For that reason, we further assume that nominal GDP is identical across markets; that is, we let $\Upsilon_m = \Upsilon$.[25] In addition, we normalize $\Upsilon = 1$.

Life evolves along an infinite discrete-time horizon $t = 1, 2, .., \infty$. In each period t, a mass $\widetilde{\rho}_q > 0$ of newly designed varieties of quality $q = l, h$ becomes available. For simplicity, we assume that $\widetilde{\rho}_q = \widetilde{\rho}$ for both $q = l, h$. We also assume that delaying the

[25] This essentially amounts to assuming that while countries may differ in their per capita nominal income (Y_m) and population (H_m), the product $Y_m \times H_m$ is equal to Υ for all m. As we show in Section 8, the model is robust to relaxing this restriction.

introduction of a newly designed model is not feasible. At the beginning of each period t, a share $\delta_q = \delta \in (0,1)$ of the varieties of quality q already present in $t-1$ in a given market m are randomly removed forever from that market. In other words, a variety present in a market in $t-1$ faces a probability δ of exiting that market in t.

To keep the dynamic analysis relatively simple, we assume that *only one* market can be entered as the first market in any period t. Conversely, we allow producers of a variety first introduced in period t to expand their market coverage (if desired) to multiple additional countries as 'second markets' in period $t+1$. However, we will restrict any market expansion to a single round, that is, for a variety first introduced in period t, subsequent market entry takes place only in the following period $t+1$.[26]

5.2.1 World economy geography and entry costs

We assume that $\mathcal{W}$ exhibits a "fractal" geographic structure. Specifically, regardless of its income level (y_p or y_r), each country $m \in \mathcal{W}$ is surrounded by two *neighboring* countries, one inhabited by low-income households and the other by high-income households. In addition to its *neighboring* countries, each m also has two *nearby* (albeit non-neighboring) countries, which are again characterized by different levels of household income. We denote by m_{dp} (resp. m_{dr}) the low-income (resp. high-income) market located at a distance d from m. We normalize the distance between m and each of its neighbors to be equal to zero ($d=0$). The two nearby markets are located equidistantly at $d=1$.

We will refer to all remaining markets in the set $\mathcal{W}$ as *faraway* markets assumed to be located at a distance greater than one ($d>1$) relative to m. Lastly, when considering any pair of countries $m, m' \in \mathcal{W}$, with $m \neq m'$, we assume that the sets $\{m_{0p}, m_{0r}\}$ and $\{m'_{0p}, m'_{0r}\}$ will have at most one element in common. Analogously, the sets $\{m_{1p}, m_{1r}\}$ and $\{m'_{1p}, m'_{1r}\}$ also share at most one element.[27]

[26] Allowing multiple (simultaneous) first markets of entry or more than one round of market expansions would rapidly increase the dimensionality of the choice set faced by firms rendering the theoretical model essentially intractable. In particular, relaxing any of these two assumptions would mean that a firm's optimal plan must take into account all possible period-by-period deviations in terms of market entry sequences. A similar problem is dealt with empirically by Morales et al. (2019) who rely on moment inequalities derived using Euler's perturbation method in discrete time.

[27] At first glance, such a geographic structure appears ad-hoc, but the purpose is to build a framework in which all markets are (ex-ante) identical from the viewpoint of a generic producer of a new variety except for their incomes and exact realizations of the entry cost (see Assumptions 3 and 4 below). In particular, we wish to ensure that within the framework the producer of a new model j designed in the period t will optimally choose j's first market in t without regard for strategic considerations about future market expansions in $t+1$. The numerical analysis in Section 8 shows that the model is robust to relaxing this specific geography.

If m is chosen as the first market of entry for a new variety j, its producer must incur an entry cost of $\phi_{jm} > 0$. We impose the following structure governing the first market entry costs:

Assumption 3 (entry cost: first market of entry). *When a newly designed variety j enters market m as its first market, the producer incurs an entry cost ϕ_{jm} independently drawn from a probability distribution with cdf $F(\phi)$, which satisfies: i) $F(\underline{\phi}) = 0$, ii) $F(\overline{\phi}) = 1$, and iii) $F'(\phi) > 0$ for all $\phi \in [\underline{\phi}, \overline{\phi})$, where $0 < \underline{\phi} < \overline{\phi}$.*

A variety j initially introduced in market m in period t, and not withdrawn from this market in $t+1$, may subsequently enter new destinations in $t+1$. To do so, j's producer must incur additional entry costs. We assume that market expansion costs will be influenced by the distance to the initial market of entry. More specifically:

Assumption 4 (entry costs: market expansions). *Consider a variety j, first introduced in market $m \in \mathcal{W}$ in period t. If variety j enters market $m' \in \mathcal{W}$, with $m' \neq m$, in period $t+1$, its producer must incur an entry cost $\varphi_{jm'}$, where:*

i) Neighboring markets — If $m' \in \{m_{0p}, m_{0r}\}$, then $\varphi_{jm'}$ is independently drawn from a probability distribution $G_0(\varphi) = G(\varphi)$ such that $G(0) = 0$ and $G'(\varphi) > 0$ for all $\varphi \geq 0$;

ii) Nearby (non-neighboring) markets — If $m' \in \{m_{1p}, m_{1r}\}$, then $\varphi_{jm'}$ is independently drawn from a probability distribution $G_1(\varphi) = (G(\varphi))^{\lambda}$, where $\lambda > 1$;

iii) Faraway markets — If $m' \notin \{m_{0p}, m_{0r}\}$ and $m' \notin \{m_{1p}, m_{1r}\}$, then $\varphi_{jm'} = \infty$.

Assumption 4 implies that expanding the market coverage of variety j beyond m involves additional entry costs. As $G_0(\varphi)$ first-order stochastically dominates $G_1(\varphi)$, these costs are likely to be smaller in neighboring markets than in nearby markets. Note also that Assumption 4.iii means that it will never be profitable to enter a faraway market.

For the sake of tractability, in what follows we let the "exit rate" δ be small enough to ensure that entry in some market m will always be profitable for the producer of a newly designed variety.[28] As a result, in each period t the mass $\widetilde{\rho}$ of newly designed varieties of each quality level will always enter some market within the set $\mathcal{W}$ for the first time. To ease notation, we henceforth let $\rho \equiv \widetilde{\rho}/M$, which equals the mass of new models (of each of the two quality levels) per country in the world on each date.

[28]This assumption is posed essentially to ensure that the present value of the flow of expected profit upon entry of a newly designed variety in period t, given probability of survival until period $\tau \geqslant t$, namely $(1-\delta)^{\tau-t}$, will be large enough to justify entry in some market $m \in \mathcal{W}$ even when the entry costs is equal to $\overline{\phi}$. None of the main results in this section depend crucially on this assumption.

5.2.2 Market entry dynamics

We focus on equilibrium dynamics along a *steady state* characterized by a constant mass of varieties of each quality level in each market m. We further restrict the analysis to *symmetric* steady states, where the mass of varieties of a given quality level is identical across markets with the same income. We let henceforth N_{qr}^* (resp. N_{qp}^*) denote the steady-state mass of varieties of quality $q = l, h$ in a market with income y_r (resp. y_p).

Let also Λ_{qy} denote the (intertemporal) expected profit flow generated by a variety of quality q in a market with consumer income y. Given the exit rate δ, the expression in (11), and the normalization $\Upsilon = 1$, in steady state:

$$\Lambda_{qy}^* = \frac{1}{\delta} \frac{\left(\mu_{qy}^* - 1\right)^2}{\mu_{qy}^*}, \tag{12}$$

where μ_{qy}^* denotes now the steady state level of markups charged on varieties of quality q in a market with income level $y = y_p, y_r$.

A share $1-\delta$ among the newly designed varieties first introduced in period t will remain present in their first market of entry in period $t+1$. Those surviving varieties may undergo market expansions in $t+1$. Assumption 4 indicates that any variety $j \in \mathcal{J}_q$ first introduced in m at time t can branch out into all possible combinations between the elements of $\{m_{0p}, m_{0r}, m_{1p}, m_{1r}\}$. Additionally, it may be the case that entry cost realizations are too high such that no market expansion proves profitable. Taking into account (12), it follows that the producer of variety j will expand its market coverage to any market $m' \neq m$ for which $\Lambda_{qy}^* > \varphi_{jm'}$.

A steady state must feature equality between the total entry of varieties of quality q (either as the first market of entry of newly designed varieties or as a second market of entry during market expansions) and the exit of existing varieties of the same quality, in every market in the world economy in any period t. Let $\mathcal{P}_{qy}$ denote the probability that a country with income y is chosen as the first market of entry for a variety of quality q, and let $\Gamma\left(\mu_{qy}^*\right) \equiv G\left(\Lambda\left(\mu_{qy}^*\right)\right) + \left(G\left(\Lambda\left(\mu_{qy}^*\right)\right)\right)^\lambda$ equal the probability of varieties of quality q expanding towards a market with income y from its neighboring and nearby countries, respectively. Then, in the steady state, the following equality must hold:

$$\mathcal{P}_{qy}\rho M + (1-\delta)\,\mathcal{P}_{qy}\rho M\,\Gamma\left(\mu_{qy}^*\right) + (1-\delta)\,\mathcal{P}_{qy'}\rho M\,\Gamma\left(\mu_{qy}^*\right) = \delta N_{qy}^*, \tag{13}$$

where $y' \neq y$. To interpret (13), note that the first term on the left-hand side equals the total mass of varieties of quality q that enter a market m with income y as the first market in t, while the sum of the remaining two terms is the total mass of varieties of quality q entering market m as a second market of entry in t. In particular, the second term is the mass of varieties expanding towards m from its neighboring or nearby market having the same income levels as m (i.e., $m_{0,y}$ or $m_{1,y}$), while the third term constitutes the mass of varieties expanding toward m from its neighboring or nearby market having a different income level than m (i.e., $m_{0,y'}$ or $m_{1,y'}$).

Lemma 3 in Appendix D shows that, letting $\Delta_{qy} \equiv \Lambda_{qy} - \Lambda_{qy'}$ for a country with income y and $y' \neq y$, where Λ_{qy} and $\Lambda_{qy'}$ are as in (12), we get:

$$\mathcal{P}_{qy} = \Phi\left(\Delta_{qy}\right), \tag{14}$$

where $\Phi(\Delta_{qy})$ is an increasing function of Δ_{qy} and $\Phi(0) = 1/M$. That is, the probability that a market m with income level y becomes the first market of entry of a variety $j \in \mathcal{J}_q$ is increasing in the difference between j's intertemporal expected profit throughout its life cycle in m and the one corresponding to any other market with income level $y' \neq y$. Note that if $\Lambda_{q,y} = \Lambda_{q,y'}$, then all markets (regardless of their income level) would face an identical probability $1/M$ of becoming j's first market of entry.

Restricting the analysis to the class of symmetric steady states implies that a steady state will be determined by four dynamic equilibrium conditions stemming from the country-level dynamic conditions (13). Each of the four conditions applies to a specific quality-income combination — see equations (23)-(26) in the appendix. From these we derive the following result:

Proposition 2. *There exists a unique symmetric steady state. In the steady state, high-quality varieties command higher markups in rich markets than in poor markets, whereas the opposite is true for low-quality varieties. Formally, $\mu^*_{hr} > \mu^*_{hp}$ and $\mu^*_{lp} > \mu^*_{lr}$. Furthermore, the steady state features identical markups for high- and low-quality varieties in poorer markets, which in turn implies that $\mu^*_{hr} > \mu^*_{hp} = \mu^*_{lp} > \mu^*_{lr}$.*

In the steady state, markups will vary across quality levels depending on the income of the market where varieties are sold. Furthermore, the variation of markups across quality-income combinations is non-monotonic: along the steady state, high quality varieties command greater markups in richer markets relative to those charged on varieties of low quality, but the opposite qualitative pattern is observed for varieties of low quality. However, the gap in markups in high- and low-quality varieties depends on income and is greater in richer markets than in poorer markets; that is, $\mu^*_{hr} - \mu^*_{lr} > \mu^*_{hp} - \mu^*_{lp}$.

Taking into account (14) and Λ^*_{qy} in (12), the likelihood of becoming the first market of entry of a variety of quality q is directly related to the difference in expected profits across markets. In addition, from (13) in conjunction with (14) it follows that within each of the two quality layers, the left-hand side of (13) is greater for markets that command higher markups along the steady state. These two observations lead to the following corollary.

Corollary 1. *The fact that the steady state features $\mu^*_{hr} > \mu^*_{hp}$ and $\mu^*_{lp} > \mu^*_{lr}$ implies that:*

1. *The proportion of newly designed high-quality (resp. low-quality) varieties entering a richer market as their first market is greater (resp. smaller) than the proportion entering a poorer market as their first market.*

2. *The mass of varieties of high quality (resp. low quality) offered in a richer market is greater (resp. smaller) than the mass of those varieties offered in a poorer market. That is, along the steady state, $N^*_{hr} > N^*_{hp}$ and $N^*_{lr} < N^*_{lp}$.*

5.2.3 Geographic patterns of market expansion

When market expansions are allowed, the specifics of the geographic structure of the model will play a role in subsequent market choices. In general, one implication of Assumption 4 is that expansions to neighboring markets tend to be more profitable than to non-neighboring ones. Yet, the frictions brought about by entry costs will be heterogeneous across quality layers and, in particular, will crucially depend on how markups for different qualities respond to income.

To characterize the geographic patterns of market expansions, let $S_q \in [0, 1]$ denote the ratio of the number of market expansions to non-neighboring markets over the total number of market expansions of varieties of quality $q = l, h$. Keeping in mind Assumption 4 coupled with (12), the following result obtains.

Lemma 1. *Along the steady state, the ratio of market expansions to non-neighboring markets relative to total market expansions in the world economy $\mathcal{W}$ is given by:*

$$S^*_q = \frac{\left(G(\Lambda^*_{qr})\right)^\lambda + \left(G(\Lambda^*_{qp})\right)^\lambda}{G(\Lambda^*_{qr}) + G(\Lambda^*_{qp}) + \left(G(\Lambda^*_{qr})\right)^\lambda + \left(G(\Lambda^*_{qp})\right)^\lambda}, \quad \text{for } q = l, h. \tag{15}$$

From (15) and since $\lambda > 1$, one may observe that $S^*_q < 1 - S^*_q$ for both $q = l$ and $q = h$. Put another way, irrespective of the level of quality, market expansions to non-neighboring markets are always less likely than to neighboring markets. However, in the model, the dampening effect of geographic distance on the likelihood of market expansion is stronger for lower-quality varieties than for higher-quality ones.

Proposition 3. *The share of market expansions that take place in non-neighboring markets is strictly greater for higher-quality varieties than for lower-quality ones. That is, bearing in mind (15): $S^*_h > S^*_l$.*

Proposition 3 formally characterizes the heterogeneous impact of geographic distance on market expansion choices along the quality dimension. In our model, two main factors guide these choices for an existing variety. One is geographical proximity, which tends to lower the entry cost faced by producers. The other factor is the impact of households' incomes on relative demand and equilibrium markups for different qualities through the AIDS nonhomothetic structure. The result in Proposition 3 can be interpreted as stating that the impact of geographical distance on market expansion choices becomes relatively weaker for higher-quality varieties.

The intuition behind Proposition 3 lies in the fact that the markups on higher-quality varieties increase with income and are higher than those on lower-quality varieties. As a result, geographic proximity tends to have a smaller relative impact on market expansions for higher-quality varieties, especially when producers plan to expand into other wealthy markets. As the influence of geographic proximity weakens for higher-quality varieties, income similarity will appear as a comparatively stronger force in determining where these premium varieties expand. We conclude this section with a proposition characterizing expansion pathways in terms of income similarity at different levels of quality.

Proposition 4. *Higher-quality varieties are more likely to undergo expansions toward markets with the same income level as their first market of entry than lower quality varieties.*

Proposition 4 stems from the variable markup structure in our model. Specifically, as markups depend on consumers' incomes, the selection of a second market reflects similar income-related considerations as for the initial market entry. Moreover, since markups are more sensitive to income at higher quality levels, this effect gets amplified for higher-quality varieties relative to lower-quality ones.

6 Empirical Analysis I: First Market of Entry

The dynamic model presented in Section 5.2 predicts that richer markets are more likely to be the initial market of entry for higher-quality varieties. Although the model relies on several simplifying assumptions to maintain tractability, the core mechanism linking consumer income levels to first-market-of-entry choices across quality levels derives from the presence of variable markups. Specifically, the nonhomothetic framework yields demand functions where the price elasticity of higher-quality varieties is more sensitive to variations in income, and hence such varieties can command greater markups in richer markets. Within our dynamic framework, this in turn leads to faster entry of new varieties of high quality in richer markets.

In this section, our aim is to test whether this dynamic prediction is supported in the data. To that end, we exploit the fact that we follow the entire life cycles of the same refrigerator models across 24 European markets for annual cohorts 2009-2013.

6.1 Market entry: Empirical framework

Collapsing the longitudinal data into a cross section of products alongside the first dates in which they enter each of their respective markets yields product-specific sequences of countries in which products are sold throughout their life cycles. These sequences can be interpreted as 'rankings' of firms' preferred locations of entry for their products, with an *earlier* presence in a particular location indicating a more desirable choice out of a set of available alternatives.

To empirically assess the dynamics patterns of entry, we let each product j face a choice set Ω_j of size C_j consisting of countries (alternatives) where it can be launched. Given the dataset's coverage, we consider that producers must decide the timing of entry into (potentially) all 24 European markets present in the dataset, such that $\Omega_j = \Omega$ and $C_j = C = 24$ for all j. Furthermore, each country $m \in \Omega$ is associated with a number of characteristics such as income per capita, population, and level of infrastructure, among others. Since products' life cycles start and end at different times, the markets' characteristics will be time dependent. These can be summarized by a vector $\mathbf{X_{mt}}$. A crucial element of $\mathbf{X_{mt}}$ in our context is the level of income per capita of country m in period t, namely y_{mt}. We also let each product comprise a set of product-specific attributes, where the most relevant in our context is its quality level q_j.

The producer of model j to be first introduced at time t will rank countries based on the revenue stream potential of product j in country m, denoted by R_{jmt}. We let R_{jmt} comprise a deterministic component (V_{jmt}) and a random component (ϵ_{jmt}):

$$R_{jmt} = V_{jmt} + \epsilon_{jmt}. \tag{16}$$

The deterministic component V_{jmt} is assumed in turn to be additive and linear in the vector $\mathbf{X_{mt}}$, in the set of product-specific attributes, and also in a set of interaction terms between $\mathbf{X_{mt}}$ and q_j. We henceforth subsume the set of product-specific attributes (herein the quality index q_j) within a set of product fixed effects denoted by ζ_j. More specifically, we let V_{jmt} be given by:

$$V_{jmt} = \Theta \cdot \mathbf{X_{mt}} + \Gamma \cdot (\mathbf{X_{mt}} * q_j) + \zeta_j + \gamma_m, \tag{17}$$

where in addition to the previously described terms in (17), V_{jmt} also includes a set of country dummies γ_m which absorb all country-specific constant characteristics that may influence the overall intensity of entry of new products in country m.[29]

[29] The country dummies γ_m will, for instance, capture the fact that the specific geographic location or tariff structure of certain countries may make them more likely to become earlier

Let $r_{jmt} = 1$ denote the case in which a producer chooses m as the first market of entry for product j in period t. That means $R_{jmt} \geq \max\{R_{jm't}, ..., R_{jCt}\}$. Assuming further that all random terms ϵ_{jmt} are independent, the probability that country m is the first market most preferred for product j would be given by:

$$Pr(r_{jmt} = 1) = \prod_{m' \neq m}^{C} Pr(\epsilon_{jm't} < (V_{jmt} - V_{jm't}) + \epsilon_{jmt}) \tag{18}$$

To operationalize the extreme value probability expression in (18) we further assume that all random terms follow an extreme value type-1 distribution.[30] Therefore, (18) boils down to the standard logit choice probability; namely:

$$Pr(r_{jmt} = 1) = \frac{e^{V_{jmt}}}{\sum_{k=1}^{C} e^{V_{jkt}}}, \tag{19}$$

where the values of each V_{jkt} in (19) are given by (17) with $k = m$. The first set of regressions used to test the predictions of the model (Corollary 1) will follow this empirical framework. Specifically, we will estimate a conditional logit model (CLM) to examine whether higher-quality products are more likely than lower-quality ones to enter richer markets first.

The above empirical strategy follows from the implicit logic of the theoretical model, which yields predictions regarding the first market of entry while abstracting from the geographic structure of the world economy. Nevertheless, resorting to a CLM means disregarding potentially useful information contained within the entire sequence of market entry over products' life cycles. This sequence could be rationalized as informative of a complete rank of preferences over entry choices. With ranked preference data, an econometric model for estimating the influence of specific variables associated with products/countries on the locations-of-entry process is the rank-ordered logit (ROL).

Let now r_{jmt} denote the rank assigned to a given market m for product j to be introduced first in period t. The complete ranking of countries/alternatives for product

markets for new models. They would also control for the fact that certain countries may host the production of larger sets of brands.

[30] The match between ϵ_{jmt} and the random component in the theoretical model for entry costs posed by Assumption 3 is not perfect as we have assumed that entry costs are independently drawn from a bounded probability distribution with support over a subset of $\mathbb{R}_+$, while the extreme value type-1 distribution is an unbounded distribution defined over the entire set $\mathbb{R}$. Naturally, we let ϵ_{jmt} follow such a distribution so that we may obtain a known closed-form solution for the empirical expression (18) that we may then be able to bring to the data. However, one could interpret the random component ϵ_{jmt} as absorbing not only the impact of entry costs but also other sources of possible product-destination-time specific randomness in demand factors.

j is given by $r_j = (r_{jm_1t}, r_{jm_2t}, ..., r_{jm_Ct})$ if all alternatives are ranked fully in subsequent order. Consequently, the probability of such a ranking is:

$$L_j = Pr(R_{jm_1} > R_{jm_2} > ... > R_{jm_C}) = \prod_{j=1}^{C} \left[\frac{e^{V_{jmt}}}{\sum_{k=1}^{C} \rho_{mk} e^{V_{jkt}}} \right], \tag{20}$$

where $\rho_{mk} = 1$ if $r_{jm} > r_{jk}$, and zero otherwise.

Implementing (20) requires a complete sequence of entries for each product in the dataset. Table C.5 in the appendix outlines how country sequences (ranks) are generated for each product based on the first-ever date of entry in a given market, $\tilde{d}_j$, and first dates of entry in any subsequent markets. The market entry order is the same for countries in which a product is introduced on the same date. The Rank variable is then constructed by assigning a value of 24 to the first market(s), 23 to the second market(s), and so on until the last market of entry, which is product-specific (i.e., market sequences will have different depths across products).[31]

One last caveat to mention is that the ROL cross-sectional framework assumes that decisions regarding a product's geographical coverage are made once and for all, rather step by step at different points in time. This assumption seems reasonable in our context, given the maturity of the sector. The top 19 brands in our dataset –accounting for 90% of the sample– are well-established and generally active in all 24 EU markets studied. Firms with extensive exporting experience such as those we study are likely to have good knowledge of their profitability potential in various destinations, allowing for an ex ante profit-maximizing selection of market sequences before observing actual performance in individual locations. Crucially, assuming pre-determined sequences remains consistent with staggered entry in practice, as the timing of decisions about rollouts may differ from their actual implementation.

6.2 Choice of first (earlier) market(s)

First market selection. We start with specifications focusing solely on the first market of entry. Specifically, we implement the conditional logit model (CLM). Note that the CLM can flexibly account for products with two or more simultaneous first markets of entry in the estimation.

The results of the CLM specifications are reported in Panel A of Table 4. These include log income and its interaction with the quality estimate as explanatory variables. The interaction term allows for a differential impact of income per head on the choice of

[31] The ranking information may be incomplete at the bottom, as some products may not end up entering all 24 countries over their life cycles.

first markets at different levels of quality. The estimation implicitly controls for product fixed effects by specifying products as an identifier variable. In (2), we further include country fixed effects, which capture non-time-varying country-level confounders such as geographic proximity to main manufacturing hubs, differences in taxation, and others. Except for Serbia, all countries in the period under consideration were part of the EU. As a result, there are virtually no differences in legal requirements, tariffs, and barriers to trade at the country level.

The specifications in columns (1) and (2) both yield a positive and statistically significant estimate of the interaction term between income and quality, the main coefficient of interest. This finding aligns with the model's predictions: premium-quality products are more likely to enter first higher-income markets than lower-quality ones. The log income coefficient also appears as positive and statistically significant in those specifications. However, this result is not robust across alternative specifications. When additional controls are introduced, the coefficient on income often becomes statistically insignificant.

A potential concern with the previous results is that they may be essentially reflecting *supply-side* factors. In particular, if products are often first introduced in the country where they are manufactured, then disentangling demand-driven from supply-driven determinants of market entry becomes problematic. Ideally, to tackle this crucial issue, we would observe the exact production location for every product in our sample, which would allow us to directly control for the country of manufacture. Since collecting such detailed product-level data is infeasible on a large scale, we instead use information on brand production locations, reported in Appendix C.2 and Table C.6. We treat all countries in Europe in which a brand manufactures fridges as possible production sites and then restrict estimation to subsamples where the first market of entry is clearly not the country of manufacture. By focusing on this subsample, we minimize the risk that supply-side factors influence the observed pattern of first-market selection.

In specification (3), we implement this restriction by excluding all products whose first market of entry coincides with any of their brand's production locations. This constraint reduces the estimation sample to 67% of the original set of products. Under this specification, the effect of log income is no longer statistically significant, but the interaction term with product quality remains both quantitatively and qualitatively consistent with the benchmark estimate in specification (2). These results, based solely on first markets of entry that are export destinations, reinforce the conclusion that first-market selection is importantly driven by demand factors and cannot be fully explained by supply-side considerations.

TABLE 4. Role of Income and Quality in First (Earlier) Market Entry

	(1)	(2)	(3)	(4)	(5)	(6)
	A. Conditional logit			B. Rank-ordered logit		
ln Income	1.509***	1.458**	1.093	4.271***	4.907***	7.585***
	(0.466)	(0.646)	(0.844)	(0.562)	(0.416)	(0.916)
ln Income$\times\hat{q}$	2.008***	1.814***	1.275**	1.535***	1.050***	1.228***
	(0.548)	(0.564)	(0.527)	(0.393)	(0.383)	(0.368)
γ_m	No	Yes	Yes	Yes	Yes	Yes
ζ_j	Yes	Yes	Yes	Yes	Yes	Yes
Products	5,212	5,212	3,478	5,212	3,480	1,710
Brands	41	41	40	41	40	41
N	125,088	125,088	83,478	125,088	83,520	41,040

Notes: The method of estimation is conditional logit in (1)-(3) and rank-ordered logit in (4)-(6). The dependent variable in (1)-(3) equals one for the first market(s) of entry and zero for all the remaining countries, and it is the market sequence or Rank in (4)-(6). The method of handling ties in the rank-ordered logit is Efron's. γ_m denote country fixed-effects. Product fixed effects, ζ_j, are implicitly taken into account in the estimation by specifying the identifier variable in the conditional logit estimation, and by `cmset` in the ordered-logit model, which declares the data to be cross-sectional choice model data. In (3) and (5) the sample is restricted to products belonging to brands that either do not manufacture in Europe or, if they do, whose first market(s) of entry are not the product's European production location(s). See Table C.6 in the Appendix for production locations by brand in the period 2009-2013. In (6), the sample is reduced to annual cohorts 2009 and 2010. $\hat{q}$ is the product-specific quality index from eq. (1). Standard errors are clustered by brand. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Rank-ordered market sequences. The CLM estimates presented in Panel A of Table 4 do not take into account the additional information contained in the full product-specific temporal market sequences. Doing so requires an alternative estimation approach that also considers the choice of subsequent markets, such as the ROL. As discussed above, we interpret the temporal sequence of market entry as revealing the relative profitability potential of a given product.

Based on the above interpretation and our construction of the dependent variable 'Rank' (see Table C.5), Panel B of Table 4 employs the ranked-ordered logit model to study the determinants of *earlier* market entry. A higher rank value indicates an earlier entry into the market. The specification in column (4) incorporates product and market fixed effects. The estimation results again highlight the importance of quality for the dynamics of market entry: goods of high quality are found to enter high-income markets earlier than other destinations.

In column (5), we impose the same restriction as in (3). (See details again in Appendix C.2.) The interaction term remains positive and significant at the 1% level, although its magnitude is slightly smaller than the benchmark estimate. This result again corroborates the underlying demand-side fundamentals in market choice.[32]

Finally, in column (6) we tackle the possibility of missing data for product-specific market sequences owing to right-censoring, which can be especially pronounced for product cohorts 2012-2013, as our full panel stops in December 2013. More specifically, in (6) we report results based only on product cohorts 2009-2010, i.e., the cohorts with the most accurate and complete market sequences in the data as, for them, data for all 24 markets are available the longest. We continue to find a statistically significant earlier entry of premium goods in wealthier markets.

One last concern in the interpretation of our findings is whether the observed patterns may actually reflect specific brand-level strategies – for instance, the systematic targeting of high-income destinations by high-end brands. Should this be the case, within-brand estimates may not necessarily reflect the same relationships observed in the full sample in Table 4. Table B.4 in the appendix applies the ROL model to each of the top ten most represented brands in the sample, based on the number of distinct products. As may be observed, in most cases, even among products of the same brand, entry into countries with varying income levels differs systematically according to product quality.

6.3 Robustness to confounding factors

Despite the extensive fixed-effects structure of the specifications in Table 4, thus far we have empirically modeled the potential profit of product j in market m at time t with a single time-varying market attribute –income per capita, alongside its interaction with quality. Can other market-specific or product-market-specific covariates such as market size and brand familiarity explain away the effect of income on the market selection of high(er) quality goods? We explore the presence of confounding factors by introducing a series of covariates (and their interaction with quality) and examining the impact of their inclusion on the estimate of our main coefficient of interest. For convenience, the results are presented graphically in Figure 4, while Tables B.2 and B.3 in the appendix report a full set of coefficients for the CLM and the ROL, respectively.

We first check how our results perform once we control for market size through the inclusion of log population. Next, we consider residential energy prices to possibly gauge preferences for energy performance. We expect these to differ across consumers facing

[32]Further robustness checks were performed with the ROL model but with two additional restrictions: we further limit the sample to cases where also the second market(s) of entry are export destination(s), and to products where third markets of entry are also not manufacturing locations. In both instances, the interaction terms are statistically significant, and our confidence intervals include meaningfully sized effects.

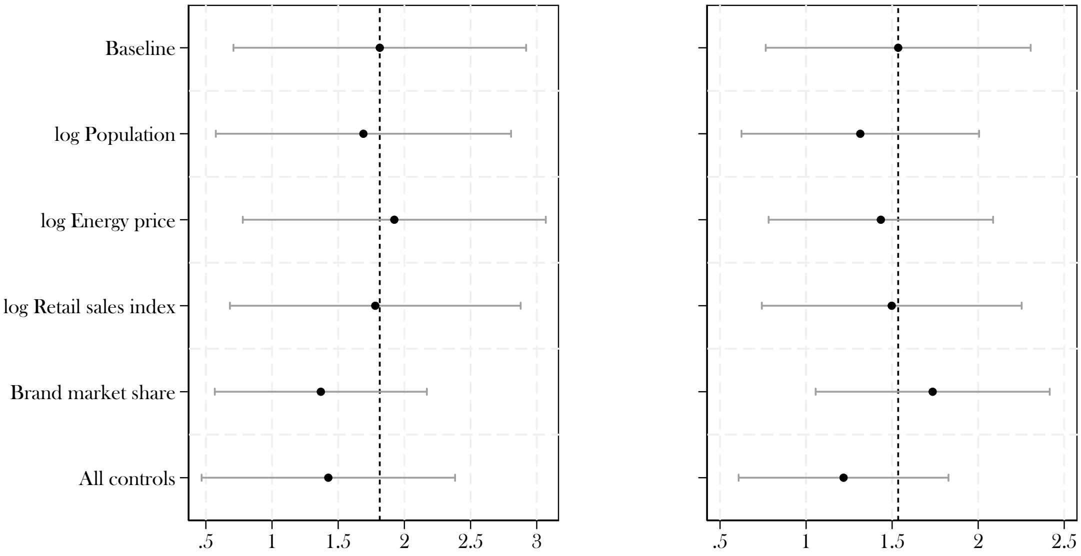
varying energy costs and may influence demand for higher quality appliances, which typically are also more energy efficient. To capture consumer sentiment and economic conditions to some extent, we also include the log of the index of turnover for retail trade. None of these variables (and their interaction with quality) influence the finding of an earlier entry into richer markets for products placed at the higher end of the quality distribution: lines 2, 3, and 4 in Figure 4 indicate that the estimate of the income-quality interaction remains very close to the baseline without additional covariates (line 1).

Next, we examine whether differential brand presence in a market can be an important confounding factor in market selection. Are new high-quality models first introduced in high-income markets because they happen to be the markets where high-quality brands have their largest market shares and thus largest consumer familiarity with their products? Market shares proxy for brand loyalty (e.g., Villas-Boas, 2004) and thereby indirectly for the degree to which public perceptions of a product belonging to a given brand are well-established (for example, perceptions of quality, environmental impact, design appeal, etc.). Brand loyalty can also go hand in hand with the presence of so-called switching costs, such as the learning costs involved in transitioning from familiar to unfamiliar brands, which consumers presumably want to avoid (e.g., Beggs and Klemperer, 1992). Differential market shares can also be indicative of the maturity of distribution networks and other related infrastructure pertaining to brand-country-specific supply chains. In this respect, they may also be informative of costs, as brands with large market shares are likely to already have long-established logistics facilities and local market knowledge, and thus potentially lower costs when placing a new product.

The market share of a brand indeed emerges as an important determinant in the choice of products' first and earlier markets as demonstrated in both Tables B.2 and B.3. However, this effect does not appear to vary with the level of quality. Despite the large estimated effect of brand market share, line 5 of Figure 4 in both plots (a) and (b) reveals that the effect of the interaction between income and quality remains still close to our benchmark estimate and highly economically relevant for market choice.

Lastly, line 6 of the figure plots the estimate of the coefficient of ln Income x Quality when all of the above covariates themselves alongside their interactions with quality are included in the estimation. Once again, our coefficient of interest remains virtually unchanged.

FIGURE 4. Effect of ln Income x Quality: Alternative Specifications



(a) Conditional logit: Choice of first market

(b) Rank-ordered logit: Choice of market sequence

Notes: The figure plots conditional-logit estimates (a) and rank-ordered logit estimates in (b) of the interaction term of the log of income with the product-specific quality estimate for models that include log population. the log of household energy prices, the log of retail sales index (100=2009), the brand market share, and all of the above controls. In all specifications, the interaction term(s) of the respective covariate(s) with quality is also included. Coefficient estimates are reported in Tables B.2 and B.3 in the Appendix. The dashed line denotes our baseline estimate from column (2) in Table 4 in (a) and column (6) from the same table in (b). 95% confidence intervals are also depicted.

7 Empirical Analysis II: Geographic Distance and Market Expansions by Quality

Our model predicts a heterogeneous impact of geographic distance on market expansion decisions for different quality layers. More precisely, Proposition 3 states that while geographic frictions make market expansions more likely in locations contiguous to the first market of entry, those frictions become relatively less pressing for higher-quality varieties than for lower-quality ones. Figure 4 provided a quick snapshot suggesting that the average distance of market expansions is wider at higher quality levels, especially in the cases of the second market entry. This subsection will offer a more exhaustive econometric analysis of the relationship between geography and market expansion choices guided by the results in Section 5.2.

In the model, we imposed a series of simplifying assumptions for the sake of analytical tractability. Two assumptions, in particular, require further discussion before making contact with the data. Firstly, we assumed that only one market may be selected as the first market of entry. Secondly, we imposed a ("fractal") geographic structure in which all markets are "geographically identical" in terms of location relative to other markets with a given income level. Neither assumption is in fact crucial to the prediction that geographic distance matters relatively less for expansion decisions at higher levels of quality; the underlying reason for this result rests actually on the variable equilibrium markups stemming from our nonhomothetic demand structure. However, to empirically assess the validity of the main result in Section 5.2, we need now to account for the following two facts: i) the dataset includes instances with multiple first markets of entry; ii) the geographic distribution of the 24 countries in the dataset is country-specific (in particular, neither every single country has the same number of neighboring countries, nor the distribution of income of their respective neighbors is identical for all).

To account for the possibility of multiple first markets of entry on a given date, we let $\Phi_j \subseteq \Omega$ denote the subset of markets within Ω (the set of 24 European countries in the panel) where variety j was first introduced. [33] Notice that there are in total as many different compositions of the sets Φ_j as combinations of first market(s) of entry present in the data.[34] In the benchmark regressions, we will treat all varieties equally, regardless of the size of the set Φ_j. However, we will control for the set of first markets of entry by including a full set of fixed effects for all combinations of Φ_j present in the data.

Denote by $\Theta_j \subset \{(\Omega - \Phi_j) \cup \emptyset\}$ the subset of market(s) —possibly empty— where variety j is subsequently introduced as second market(s) of entry. There are 4,213 (80.8%) models for which $\Theta_j \neq \emptyset$. These models represent our relevant benchmark sample for the regressions in this section.[35] Considering $m \in \Phi_j$ and $m' \in \Theta_j$, we can define $\mathbb{I}_j(m, m') : \Phi_j \times \Theta_j \to \{0, 1\}$, such that $\mathbb{I}_j(m, m') = 1$ if and only if m' and m are neighboring countries. Henceforth, we will consider a market expansion to m' to be a 'non-neighboring market expansion' if and if only this market does not share any border with any of model j's first markets of entry; that is, if and only if $\mathbb{I}_j(m, m') = 0$ for all $m \in \Phi_j$. As a result, the share $S_j \in [0, 1]$ of market expansions that take place in non-neighboring

[33] There are a total of 5,212 different varieties. The set Φ_j comprises one single element (i.e., there is one single first market of entry) in 76.8% of the sample, two elements in 16.1%, three in 4.2%, four in 1.9%, and five, six and seven elements for 0.7%, 0.2% and 0.1% of the sample, respectively.

[34] There are 165 different combinations of 'first market(s) of entry' present in our dataset. Note that if the set of 'first market(s) of entry' of two different varieties j and k are identical, then $\Phi_j = \Phi_k$.

[35] Amongst the 4,213 models that exhibit a market expansion during the sample years 2009-13, 74% has one single element in Θ_j, 15.8% has two elements, 5.8% three elements, 2.4% four elements, and 1%, 0.5%, 0.2%, and 0.1% have five, six, seven and eight elements, respectively. The remainder are a few odd cases in which Θ_j comprises 9, 10 and 11 markets.

countries relative to the total number of market expansions for model j is given by:

$$S_j = \frac{\sum_{m' \in \Theta_j} \left(1 - \max_{m \in \Phi_j} \{\mathbb{I}(m, m')\}\right)}{\#\Theta_j}, \tag{21}$$

where $\#\Theta_j$ is the number of elements of Θ_j.

Our benchmark regression in Table 5, column (1), shows the results of the following OLS regression:

$$S_j = \textit{constant} + \beta \cdot q_j + \psi_{\Phi_j} + \varepsilon_j, \tag{22}$$

where each S_j stems from (21), q_j is the level of quality characterizing variety j, and ψ_{Φ_j} denotes a complete set of fixed effects for each combination of 'first market(s) of entry' present in the dataset. Note that by including ψ_{Φ_j}, we control for the fact that each country has different sets of neighboring countries with varying characteristics (and, in particular, with different incomes per capita). Since these factors may expectably be correlated with q_j, we wish to explicitly control for the exact set of countries in which each model was first introduced and exploit only the variation in quality within each of them. Notice that ψ_{Φ_j} will also take into account that a larger set Φ_j will tend to (mechanically) have more neighboring markets, although at the same time there will be less scope for total expansion (as a smaller number of markets are possibly left for expansion within the original set of 24 countries), which in turn will affect both the numerator and the denominator in (21).

The result of the OLS regression (22) reported in column (1) yields a positive and significant estimate of β. This means that, abstracting from variations in the set of first markets of entry Φ_j, the share of expansions that take place in markets that are non-neighboring to any of the first markets of entry is greater for models of higher quality.

In terms of its quantitative impact, denoting by q_X the value of the quality measure at the X^{th} percentile, and computing the value of $\hat{S}(q_X)$ based on the estimates in column (1) for the set Φ_j for which $\hat{\psi}_{\Phi_j} = 0$, we have $\hat{S}(q_5) = 0.372$ and $\hat{S}(q_{95}) = 0.462$.[36] Within our sample of 24 European markets, the average number of non-neighboring markets is 21.5. The results for $\hat{S}(q_5)$ and $\hat{S}(q_{95})$ then suggest that market expansions are in general much more likely to involve contiguous markets, but also that the quantitative difference in the probabilities of non-contiguous market expansions across top and bottom qualities is nonetheless quite wide. That is, our results confirm that geographic distance matters when

[36] The value of those quality indices stemming from our Hedonic price regressions are q_5=-0.519 and q_{95}=0.938.

TABLE 5. Non-neighboring Market Expansions, Distance, and Quality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Share Non-neighboring				Average Distance			
Quality	0.061***	0.055***	0.059***	0.060**	82.4***	50.9***	45.5**	49.4**
	(0.015)	(0.014)	(0.021)	(0.025)	(14.64)	(11.2)	(18.7)	(22.5)
Constant	0.404***	0.385***	0.384***	0.407***	810***	775***	776***	784***
	(0.006)	(0.006)	(0.007)	(0.008)	(5.8)	(5.3)	(5.8)	(6.8)
1st market(s) fe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2nd market(s) fe		Yes	Yes	Yes		Yes	Yes	Yes
Brand fe			Yes	Yes			Yes	Yes
Observations	4,213	4,213	4,213	2,943	4,213	4,213	4,213	2,943

Notes: The dependent variable in columns (1)-(4) is the share of non-contiguous market expansions to a second market of entry, whereas in columns (5)-(8) is the distance between second market(s) of entry and the first market(s) of entry (computed as an average in the case of multiple first market of entry). Specifications (4) and (8) are performed on the subsample of models for which the country of manufacturing is not a first market of entry, following the analysis in Appendix C.2. Robust standard errors reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

evaluating where to further expand the market penetration of new products. However, they also show that the influence of such "gravity pull" declines at higher levels of quality.

In column (2) we add to the benchmark regression specification (22) a full set of fixed effects for all the combinations of 'second market(s) of entry' present in the data. These fixed effects will control for the fact that certain countries may tend to be more regularly those where market expansions take place after the initial entry of a new model. In addition, these fixed effects will account for the specificities of the geography of each country, which will differ in terms of the number of neighboring countries (and their levels of income).[37] Next, in column (3) we also include a set of brand fixed effects. The reason for this would be to control for the possibility that certain brands may in general be more regularly present in certain markets. Since different brands tend to vary as well in terms of the range of quality of models they offer to consumers, an uneven geographic distribution of brand presence could represent a source of bias toward the results. As we can observe from columns (2) and (3), both the magnitude and statistical significance of the estimate for the coefficient of interest remain quite stable.

The specifications in columns (1)-(3) exploit a binary distinction between neighboring vs. non-neighboring pairs of countries. Although this approach has the appeal of highlighting the fluidity of sharing a border, it overlooks important aspects of the

[37]Note that the set of fixed effects in column (1), ψ_{Φ_j}, had controlled for the geographic specificities of the 'first market(s) of entry' but not for those of the 'second market(s) of entry'.

geography of countries in our dataset. One is that the dependent variable treats all pairs of non-contiguous countries identically regardless of how distant they are from each other.[38] Analogously, all contiguous countries are also treated identically, as if they all share an equally long border and have their entire populations sitting side by side across their common border.

To account for these nuances, in columns (4)-(6), we replace the dependent variable S_j in (21) by one that reflects the average distances between markets. For each pair m and m', we use their bilateral weighted geographic distance $dist\,(m, m') = dist\,(m', m)$, where weights are based on city-level population distribution in each of the two countries.[39] Based on the bilateral distances, we define $Mean\_Dist_j = \frac{1}{\#\Theta_j} \cdot \sum_{m' \in \Theta_j} \left(\frac{1}{\#\Phi_j} \cdot \sum_{m \in \Phi_j} dist\,(m, m') \right)]$ to be used as the dependent variable in specifications (4)-(6).

All results remain qualitatively in line with those in columns (1)-(3). In terms of its quantitative interpretation, the estimate for β in column (1) entails that the average distance between the first market(s) of entry and those to where the first wave of market expansion takes place tends to be approximately 17% greater for the variety in 95^{th}-percentile of quality than for the variety in 5^{th}-percentile of quality.

The previous results demonstrate that market expansions for higher quality products tend to occur farther away from the initial entry markets. If these initial markets overlap with the country of manufacture, one plausible explanation for this pattern is the Alchian-Allen effect (Alchian and Allen, 1964), often referred to as 'shipping the good apples out'. This hypothesis states that, when faced with per-unit transaction or shipping costs, producers find it more profitable to sell higher-quality versions of their products in more distant markets [see, e.g., Hummels and Skiba (2004), Baldwin and Harrigan (2011), and Crozet et al. (2012)].

From one perspective, our findings on the geography of market expansions can be seen as a dynamic extension of the static Alchian-Allen effect. However, our model goes further, offering additional predictions beyond the traditional "shipping the good apples out" framework. According to our model, the observed greater distances between initial entry markets and subsequent expansion markets for higher quality varieties result from nonhomothetic demand factors pulling more strongly against gravity forces for premium products than for entry-level ones. This interplay –or "tug-of-war"– between variable

[38] That means we are treating an expansion from Germany to Italy as equal to one from Germany to Portugal, even though the shortest distance between the former is 70 km while between the latter is almost 2000 km.

[39] Bilateral distance data are sourced from CEPII database – see Conte, Cotterlaz and Mayer (2022).

markups and gravity effects occurs regardless of the manufacturing country's location. As a result, our model predicts similar patterns in the average distance of market expansions, regardless of whether or not the first entry market coincides with the manufacturing country. We term this broader pattern as "spreading the good apples out."

To test whether the data are also consistent with this idea, we leverage the brand-level production locations summarized in Appendix C.2 to conduct two additional regressions based on the subsample of products for which we can be certain that the country of manufacture differs from the initial market of entry. Columns (4) and (8) replicate those in columns (3) and (7), respectively, based now on the restricted subsample of products. Notice that, in this specific setting, the inclusion of brand fixed effects also controls for the distribution of manufacturing locations across brands in the sub-sample. These last two results show that even when focusing on products initially launched outside of their country of manufacture, geographic proximity still plays a relatively smaller role in market expansion decisions for higher-quality products.

Geographic Distance vs. Income Similarity

Combining insights from Propositions 3 and 4, our model predicts that as product quality increases, income similarity becomes a more significant driver of market expansion than geographic proximity. The interplay between these two different forces results in the "spreading the good apples out" pattern observed in market rollouts, where income-dependent demand gradually outweighs the pull of geographic closeness at higher quality levels. We conclude this section by examining whether the pattern of expansion –from the first market(s) of entry to the second market(s) of entry– aligns with these predictions.

To that end, Table 6 presents a series of conditional logit regressions in which the dependent variable is the binary indicator $Second_{jm}$, equal to one if country m is among the 'second market(s) of entry' of model j (i.e., if $m \in \Theta_j$), and zero otherwise. Because we aim to analyze market rollout patterns following the initial entry, we exclude all observations corresponding to the first market(s) of entry (Φ_j) for each model j.

In terms of covariates, columns (1) and (2) include the dummy variable $contig_{jm}$, which equals one if country m is contiguous to at least one country in j's set of first market(s) of entry (Φ_j), and an interaction term $contig_{jm} \times q_j$, where q_j denotes the quality of j. Columns (3) and (4) replace $contig_{jm}$ with $dist_{jm}$, the (log) distance between m and the nearest country within the set Φ_j. In addition, all specifications include the variable $linder_{jm}$ and its interaction with quality. $linder_{jm}$ is defined as the absolute difference in log GDP per capita between country m and the log average GDP per capita among the countries within the set Φ_j, capturing the degree of *income dissimilarity* between country

TABLE 6. Market Expansions: Geographic Distance vs. Income Similarity

	(1)	(2)	(3)	(4)
linder	-2.199***	-2.775***	-2.701***	-3.169***
	(0.081)	(0.092)	(0.083)	(0.093)
linder x quality	-0.579***	-0.576***	-0.512***	-0.389**
	(0.175)	(0.189)	(0.176)	(0.187)
contig	1.374***	0.872***		
	(0.031)	(0.039)		
contig x quality	-0.292***	-0.298***		
	(0.068)	(0.076)		
dist			-0.919***	-0.702***
			(0.023)	(0.034)
dist x quality			0.358***	0.353***
			(0.049)	(0.059)
Product FE	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	Yes
Observations	95,190	95,190	95,190	95,190

Notes: The dependent variable is a binary variable equal to one when country *m* is a second market of entry for model *j*, and zero otherwise. The sample includes only markets that have not been a first market of entry of model *j* (i.e., it excludes all the observations which correspond to a first market of entry). 'contig' is a dummy variable that equals one when country *m* shares a border with at least one of the first markets of entry of model *j*, and zero otherwise. 'dist' is the (log) distance between *m* and model *j*'s first market of entry (in cases with multiple first market of entry, we use the log mean distance). 'linder' is defined as the absolute value of the difference between the log income per capita of country *m* and the log income per capita of the first market of entry for model *j*. Robust standard errors clustered at the model level in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

m and the set of initial entry markets of model j.[40] All specifications include model fixed effects, while those in columns (2) and (4) incorporate also country fixed effects.

The results in Table 6 indicate that both geographic proximity and income similarity influence second markets of entry choices. The positive (resp. negative) coefficient associated with the variable $contig_{jm}$ (resp. $dist_{jm}$) suggests that second-entry markets tend to be geographically closer to the initial markets. Likewise, the negative coefficient on $linder_{jm}$ indicates a preference for second markets with income levels more similar to those of the first market of entry. Importantly, these effects vary by quality level. In line with the findings in Table 5, the impact exerted by geographic distance weakens with the level of quality. In contrast, the effect of income similarity becomes more pronounced at higher quality levels. Specifically, the negative coefficient associated with the interaction term $linder_{jm} \times q_j$ signals that the influence of income similarity plays a progressively stronger role in guiding market expansion as quality increases.

8 Numerical analysis

In this section, we extend the model developed in Section 5 by calibrating it to the European refrigerator market and drawing on the preceding empirical analysis. The quantitative framework relaxes some of the restrictive assumptions of the stylized model in order to better capture the European context. In particular, we allow countries to differ not only in per capita income but also in total GDP, and we drop the assumption that markets are located on a fractal geography.

Calibration strategy

We maintain the two-market-type/two-quality-tier structure of the analytical framework. The markets and fridge models are divided by income and quality levels as described in Section 4 and Section 2, respectively. For each market tier, we construct a representative market that reproduces the main moments of the 12 European countries in that subset. Table 7 summarizes the targeted moments: the rich-to-poor ratios of real and nominal GDP (Items 1.1-1.2), the average number of neighbors by income type (1.3-1.5), the quality differential (1.6), and three indicators that govern product turnover (1.7) and spatial diffusion (1.8-1.9).

[40]More formally, $linder_{jm}$ is given by $\left|\ln y_m - \ln y_{\Phi_j}\right|$, where y_m is the income per capita of country m, and $\ln y_{\Phi_j} = \ln\left(\frac{1}{\#\Phi_j}\sum_{k\in\Phi_j} y_k\right)$, with $\#\Phi_j$ denoting the number of elements of the set Φ_j and $k \in \Phi_j$ indexing the countries in the set of first market of entry for model j.

TABLE 7. Calibration targets

Item	Notation	Target	Value
1.1	y_r	ratio of rich-to-poor market real per capita GDP	1.7145
1.2	Υ_r	ratio of rich-to-poor market aggregate GDP	5.1150
1.3	$\theta_{pp'}$	poor market's number of poor neighbors	2.3333
1.4	$\theta_{yy'}$	number of neighbors of market with income $y = p, r$ in the subset of markets with income $y' \neq y$	0.5833
1.5	$\theta_{rr'}$	rich market's number of rich neighbors	2.0833
1.6	$h - l$	number of models ratio (low-quality in rich market to high-quality in poor market)	1.8903
1.7	δ	share of withdrawn fridge varieties	0.2500
1.8	$\overline{\varphi}$	fraction of fridge varieties that expand to further markets (after their first entry)	0.8080
1.9	λ	fraction of non-neighboring expansion markets (out of the total count of expansions)	0.4144

Notes: The table reports the empirical targets used in the calibration. The first column enumerates the targets. The second column identifies the relevant theoretical item using the model's notation. The third column describes the empirical target used to calibrate the theoretical item. The fourth column reports the observed values of the targets.

Because entry and expansion costs are not directly observable in our dataset, we pin down Items 1.8-1.9 indirectly, by requiring the calibrated model to reproduce (i) the share of varieties that expand beyond their first destination and (ii) the fraction of expansions into non-neighboring markets. These values are drawn from the empirical work discussed in Section 7, according to the results presented in Table 5. Similarly, the quality differential (Item 1.6) is picked indirectly and set so that the model matches the observed ratio between low-quality models sold in rich markets and high-quality models sold in poor ones.[41]

Numerical results

Table 8 compares the predictions of the calibrated model with their empirical counterparts. Specifically, for each item listed in the first column, the third column reports the simulated values identified in the second column using the model notation. The observed values are reported in the fourth column, with their definitions provided in the fifth column. For ease of interpretation, note that a model abstracting from nonhomotheticities linked to quality would predict that Items 2.2-2.5 equal one and Items 2.6-2.7 coincide. Relative to such a homothetic scenario, the calibrated model accounts

[41]Additional technical details on the calibration strategy are reported in Appendix E.

TABLE 8. Numerical results

Item	Notation	Cal	Obs	Description
2.1	$\rho/\bar{N}$	0.118	0.101	ratio of newly introduced to total mass of models
2.2	N_{lp}/N_{hp}	1.662	1.730	ratio of low- to high-quality models in poor markets
2.3	N_{lr}/N_{hr}	0.559	0.614	ratio of low- to high-quality models in rich markets
2.4	N^f_{lp}/N^f_{hp}	2.286	1.640	ratio of low- to high-quality first-entry models in poor markets
2.5	N^f_{lr}/N^f_{hr}	0.667	0.530	ratio of low- to high-quality first-entry models in rich markets
2.6	$\bar{S}_l$	0.374	0.372	high-quality models' fraction of non-neighboring expansion markets
2.7	$\bar{S}_h$	0.455	0.462	low-quality models' fraction of non-neighboring expansion markets

Notes: The table contrasts the predictions of the calibrated model (third column) with their empirical counterparts (fourth column) for each item enumerated in the first column and specified theoretically in the second column. The last column provides a short description of each statistic.

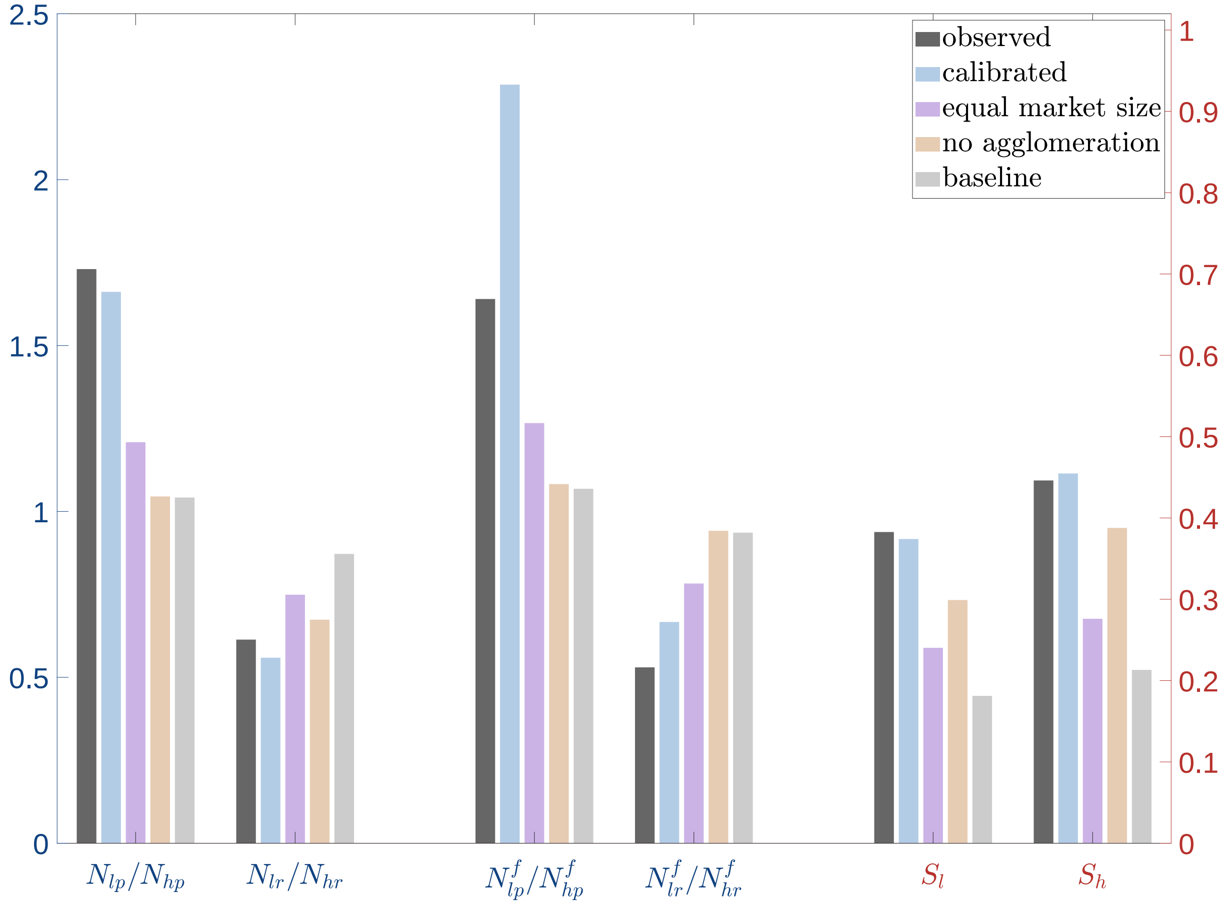
for about 86% of the observed variation. It performs particularly well in matching the quality-specific fractions of non-neighboring expansions (gap of 2.1%) and less well in capturing the ratio of low- to high-quality first-entry models in poor markets (gap of 39.4%).

We also investigate the marginal effects of market size (variation in aggregate GDP) and geographic agglomeration by income (featured by an unequal number of rich and poor neighbors). To do so, we counterfactually impose the relevant restrictions assumed in the baseline model (namely, equal GDP across countries and fractal geography). Figure 5 illustrates the results: each group of five bars corresponds to one of the outcomes in Items 2.2-2.7 of Table 8. Within each group, the first two bars, drawn for reference, show the observed and calibrated values. The remaining bars report the predictions of the calibrated model under each additional restriction, with the last bar incorporating both restrictions. The framework in the last exercise can be interpreted as a calibrated version of the baseline model, adjusted for the number of accessible expansion markets to match our dataset's spatial dimension. [42]

The figure reveals three main findings. First, the association of low quality with poor markets and high quality with rich markets declines when equal market size or no-agglomeration is imposed. Second, each assumption reduces the share of non-neighboring

[42]Specifically, we let $\theta_{yy'}$ match the average number of neighboring markets observed in the data, for each pair of income class between the first-entry market ($y = p, r$) and expansion market ($y' \neq y$).

FIGURE 5. Comparative statics: model outcomes under alternative assumptions.



Notes: The figure illustrates the effect of re-imposing, one at a time, the simplifying assumptions of the baseline model –equal market size and no agglomeration– on the calibrated framework. Each group of six bars corresponds to one of the Items in Table 8. Within each group, the first two bars, drawn for reference, show the observed and calibrated values. The following two bars show the predictions after imposing, in turn, a single additional restriction, while the last bar combines both restrictions, thus reproducing a calibrated version of the baseline model, adjusted for the number of accessible expansion markets.

expansions, with the market size scaling down producing the largest decline. Third, while the calibrated version of the baseline model reproduces the qualitative pattern of the data, it lacks sufficient variation to match the observed magnitudes, a gap closed only by the fully calibrated specification.

The counterfactual analysis illustrated in Figure 5 yields important insights regarding the variety of models a market can attract. In the context of European geography, the average low-income market is disadvantaged not only because of its lower purchasing power, but also because it is typically smaller than a high-income market and surrounded by other poor markets. The average European low-income market is estimated to lose an additional 14% of models, almost exclusively of high quality, due to its smaller size. A comparable loss arises from being located next to other low-income countries. However, in this case, the negative effect on total model count is partially offset by a 7% increase in the number of low quality models.

These findings imply that there may be relative winners and losers even within the same income class. For example, Latvia (a small low-income country bordered only by similarly poor neighbors) attracts just 37% of the average number of high-quality models that reach low-income EU markets. The calibrated model predicts that Latvia would attract 25% more high-quality models if it had the same neighbors profile as Slovenia, and as much as 50% more if it had the population of Poland. In this respect, the analysis lends itself to policy-oriented applications with both intended and unintended consequences. For example, Ireland (a small but high-income country not covered in our dataset) would have likely experienced a substantial reduction in product variety (especially of high quality) after Brexit via losing its only EU neighbor, the UK, a large and affluent market.

9 Conclusion

This paper has studied the dynamics of entry of vertically differentiated products into a world economy where market expansions face geographic frictions and consumers exhibit nonhomothetic preferences for quality. Our findings reveal that geographic proximity is a key determinant in the market expansion strategies of lower quality products. However, its importance diminishes for higher-quality products as high-end producers prioritize catering to wealthier consumers' preference for quality over spatial considerations. This distinction in strategy underscores the critical role of income distribution in shaping market expansion paths within vertically differentiated industries.

The empirical analysis of the refrigerator industry across 24 different European countries validates our model's main predictions, showing that high-quality products are indeed introduced first in wealthier countries and subsequently expanded to more distant, high-demand markets. Meanwhile, lower-quality products adhere more strictly to geographic proximity in their market entry sequences.

These results highlight how income-related preferences impact the broader structure of global trade networks and the diffusion of product innovations, with significant implications for the formulation of export strategy. By acknowledging that high- and low-quality goods tend to follow distinct geographic and income-based pathways, policymakers can tailor more refined export-promoting platforms that account for quality differences. For example, logistic support and policies aimed at overcoming trade frictions may have a much stronger impact on lower-quality versions of goods than on premium ones. However, promoting quality improvement would require an enhanced effort in the establishment of trade agreements with richer economies without an excessive concern about prioritizing geographic considerations.

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Appendix

A Proofs

Proof of Proposition 2. Bearing in mind (12) and (14), and recalling that $\Delta_{qy} \equiv \Lambda_{qy} - \Lambda_{qy'}$ and $\mathcal{P}_{qy'} = 2/M - \mathcal{P}_{qy}$, the steady-state equilibrium will be characterised by the (simultaneous) solution of the following four equations stemming from (13):

$$LP\text{-locus}: \quad \tilde{\Phi}\left(\mu_{lp}^*, \mu_{lr}^*\right) + \frac{2(1-\delta)}{M}\Gamma\left(\mu_{lp}^*\right) = \frac{\delta}{\rho M} N_{lp}^*, \tag{23}$$

$$LR\text{-locus}: \quad \frac{2}{M} - \tilde{\Phi}\left(\mu_{lp}^*, \mu_{lr}^*\right) + \frac{2(1-\delta)}{M}\Gamma\left(\mu_{lr}^*\right) = \frac{\delta}{\rho M} N_{lr}^*, \tag{24}$$

$$HP\text{-locus}: \quad \frac{2}{M} - \tilde{\Phi}\left(\mu_{hr}^*, \mu_{hp}^*\right) + \frac{2(1-\delta)}{M}\Gamma\left(\mu_{lr}^*\right) = \frac{\delta}{\rho M} N_{hp}^*, \tag{25}$$

$$HR\text{-locus}: \quad \tilde{\Phi}\left(\mu_{hr}^*, \mu_{hp}^*\right) + \frac{2(1-\delta)}{M}\Gamma\left(\mu_{hr}^*\right) = \frac{\delta}{\rho M} N_{hr}^*, \tag{26}$$

where $\tilde{\Phi}\left(\mu_{qy}^*, \mu_{qy'}^*\right) \equiv \Phi\left(\Lambda\left(\mu_{qy}^*\right) - \Lambda\left(\mu_{qy'}^*\right)\right) \in [0, 2/M]$, with $\partial\tilde{\Phi}\left(\mu_{qy}^*, \mu_{qy'}^*\right)/\partial\mu_{qy}^* > 0$ and $\partial\tilde{\Phi}\left(\mu_{qy}^*, \mu_{qy'}^*\right)/\partial\mu_{qy'}^* < 0$, and $\Gamma\left(\mu_{qy}^*\right) \geq 0$, with $\Gamma'\left(\mu_{qy}^*\right) \equiv \partial\Gamma\left(\mu_{qy}^*\right)/\partial\mu_{qy}^* > 0$. Each of these four equations represent the locus along which the mass of varieties of a given quality in markets of a given income (namely, the one depicted on the RHS of the relevant equation) remains constant over time.

Notice that (9) and (10) in Proposition 1 imply that, in a steady state, $\mu_{hp}^* = \mu_{lp}^* = \mu_p^*$ and $\mu_{lr}^* = \mu_{hr}^* - \ln y$. Furthermore, the following two relations must be verified:

$$N_{hp}^* = \frac{1}{\mu_p^* - 1} - N_{lp}^*, \tag{27}$$

$$N_{hr}^* = \frac{1}{\mu_{hr}^* - 1} - \frac{\mu_{hr}^* - 1 - \ln y}{\mu_{hr}^* - 1} N_{lr}^*. \tag{28}$$

Using (27) to equalise (23) and (25), (28) to equalise (24) and (26), and the equations $\mu_{hp}^* = \mu_{lp}^* = \mu_p^*$ and $\mu_{lr}^* = \mu_{hr}^* - \ln y$, we may reduce (23)-(26) to the system of two equations in two unknowns (namely, μ_p^* and μ_{hr}^*):

$$\begin{aligned} P\text{-locus}: \quad & \tilde{\Phi}\left(\mu_p^*, \mu_{hr}^* - \ln y\right) + \frac{2(1-\delta)}{M}\Gamma\left(\mu_p^*\right) + \frac{2}{M} - \tilde{\Phi}\left(\mu_{hr}^*, \mu_p^*\right) \\ & + \frac{2(1-\delta)}{M}\Gamma\left(\mu_{hr}^* - \ln y\right) - \frac{\delta}{\rho M}\frac{1}{\mu_p^* - 1} = 0, \end{aligned} \tag{29}$$

$$\begin{aligned} R\text{-locus}: \quad & \frac{2}{M} - \tilde{\Phi}\left(\mu_p^*, \mu_{hr}^* - \ln y\right) + \frac{2(1-\delta)}{M}\Gamma\left(\mu_{hr}^* - \ln y\right) \\ & + \chi\left(\mu_{hr}^*\right)\left[\tilde{\Phi}\left(\mu_{hr}^*, \mu_p^*\right) + \frac{2(1-\delta)}{M}\Gamma\left(\mu_{hr}^*\right) - \frac{\delta}{\rho M}\frac{1}{\mu_{hr}^* - 1}\right] = 0, \end{aligned} \tag{30}$$

where $\chi\left(\mu_{hr}^{*}\right) \equiv \left(\mu_{hr}^{*}-1\right) / \left(\mu_{hr}^{*}-1-\ln y\right) > 1$, with:

$$\chi_{hr}^{\prime} \equiv \frac{\partial \chi\left(\mu_{hr}^{*}\right)}{\partial \mu_{hr}^{*}}=\frac{1-\chi_{hr}}{\mu_{hr}^{*}-1-\ln y}. \tag{31}$$

The proof proceeds in three steps. Specifically, with reference to a $\left(\mu_{hr}^{*}, \mu_{p}^{*}\right)$ Cartesian representation, we show that: (i) if the loci ever cross each other, at that point the R-locus is steeper than the P-locus; (ii) the R-locus lies below the P-locus for sufficiently low mark-up levels; (iii) the R-locus lies above the P-locus when it crosses the $45°$ line.

Part (i). Note that the system (29)-(30) only includes $\tilde{\Phi}\left(\mu_{p}^{*}, \mu_{hr}^{*}-\ln y\right)$ and $\tilde{\Phi}\left(\mu_{hr}^{*}, \mu_{p}^{*}\right)$ as explicit first-entry probabilities. With a slight abuse of notation, we let:

$$\tilde{\Phi}_{lp}^{\prime} \equiv \frac{\partial \tilde{\Phi}\left(\mu_{p}^{*}, \mu_{hr}^{*}-\ln y\right)}{\partial \mu_{p}^{*}} > 0, \quad \tilde{\Phi}_{lr}^{\prime} \equiv \frac{\partial \tilde{\Phi}\left(\mu_{p}^{*}, \mu_{hr}^{*}-\ln y\right)}{\partial \mu_{hr}^{*}} < 0,$$
$$\tilde{\Phi}_{hp}^{\prime} \equiv \frac{\partial \tilde{\Phi}\left(\mu_{hr}^{*}, \mu_{p}^{*}\right)}{\partial \mu_{p}^{*}} < 0, \quad \tilde{\Phi}_{hr}^{\prime} \equiv \frac{\partial \tilde{\Phi}\left(\mu_{hr}^{*}, \mu_{p}^{*}\right)}{\partial \mu_{hr}^{*}} > 0,$$

Furthermore, we also let:

$$\Gamma_{p}^{\prime} \equiv \frac{\partial \Gamma\left(\mu_{p}^{*}\right)}{\partial \mu_{p}^{*}} > 0, \quad \Gamma_{lr}^{\prime} \equiv \frac{\partial \Gamma\left(\mu_{hr}^{*}-\ln y\right)}{\partial \mu_{hr}^{*}} > 0, \quad \Gamma_{hr}^{\prime} \equiv \frac{\partial \Gamma\left(\mu_{hr}^{*}\right)}{\partial \mu_{hr}^{*}} > 0.$$

Differentiating (29) and (30) yields:

$$\left(\tilde{\Phi}_{hr}^{\prime}-\tilde{\Phi}_{lr}^{\prime}\right) d\mu_{hr}^{*}=\left(\tilde{\Phi}_{lp}^{\prime}-\tilde{\Phi}_{hp}^{\prime}+A\right) d\mu_{p}^{*}, \tag{32}$$

$$\left(\chi_{hr}\left(\mu_{hr}^{*}\right) \tilde{\Phi}_{hr}^{\prime}-\tilde{\Phi}_{lr}^{\prime}+B\right) d\mu_{hr}^{*}=\left(\tilde{\Phi}_{lp}^{\prime}-\chi_{hr}\left(\mu_{hr}^{*}\right) \tilde{\Phi}_{hp}^{\prime}\right) d\mu_{p}^{*}, \tag{33}$$

where:

$$A \equiv \frac{2(1-\delta)\left(\Gamma_{p}^{\prime}+\Gamma_{lr}^{\prime}\right)}{M}+\frac{\delta}{\rho M\left(\mu_{p}^{*}-1\right)^{2}} > 0,$$
$$B \equiv \frac{2(1-\delta)\left(\Gamma_{lr}^{\prime}+\chi_{hr}\left(\mu_{hr}^{*}\right) \Gamma_{hr}^{\prime}\right)}{M}+\frac{2-M \tilde{\Phi}\left(\mu_{p}^{*}, \mu_{hr}^{*}-\ln y\right)+2(1-\delta) \Gamma\left(\mu_{hr}^{*}-\ln y\right)}{M\left(\mu_{hr}^{*}-1-\ln y\right)} > 0,$$

and in (33) we used (31) in conjunction with (30) to replace:

$$-\frac{\chi\left(\mu_{hr}^*\right)\left[\frac{2(1-\delta)\Gamma\left(\mu_{hr}^*\right)}{M}+\tilde{\Phi}\left(\mu_{hr}^*,\mu_p^*\right)-\frac{\delta}{\rho M}\frac{1}{\mu_{hr}^*-1}\right]}{\mu_{hr}^*-1-\ln y}=$$
$$\frac{\frac{2}{M}-\tilde{\Phi}\left(\mu_p^*,\mu_{hr}^*-\ln y\right)+\frac{2(1-\delta)\Gamma\left(\mu_{hr}^*-\ln y\right)}{M}}{\mu_{hr}^*-1-\ln y}.$$

Rearranging, we have:

$$\left.\frac{d\mu_p^*}{d\mu_{hr}^*}\right|_P=\frac{\tilde{\Phi}'_{hr}-\tilde{\Phi}'_{lr}}{\tilde{\Phi}'_{lp}-\tilde{\Phi}'_{hp}+A}>0, \tag{34}$$

$$\left.\frac{d\mu_p^*}{d\mu_{hr}^*}\right|_R=\frac{\chi\left(\mu_{hr}^*\right)\tilde{\Phi}'_{hr}-\tilde{\Phi}'_{lr}+B}{\tilde{\Phi}'_{lp}-\chi\left(\mu_{hr}^*\right)\tilde{\Phi}'_{hp}}>0. \tag{35}$$

From (34) and (35), we observe:

$$\left.\frac{d\mu_p^*}{d\mu_{hr}^*}\right|_P<\left.\frac{d\mu_p^*}{d\mu_{hr}^*}\right|_R. \tag{36}$$

Suppose $d\mu_p^*/d\mu_{hr}^*\big|_R\leq d\mu_p^*/d\mu_{hr}^*\big|_P$. This inequality requires:

$$\left(\tilde{\Phi}'_{lp}-\tilde{\Phi}'_{hp}+A\right)\left(\chi\left(\mu_{hr}^*\right)\tilde{\Phi}'_{hr}-\tilde{\Phi}'_{lr}+B\right)\ \leq\ \left(\tilde{\Phi}'_{lp}-\chi\left(\mu_{hr}^*\right)\tilde{\Phi}'_{hp}\right)\left(\tilde{\Phi}'_{hr}-\tilde{\Phi}'_{lr}\right). \tag{37}$$

Since $A,B>0$, (37) also implies:

$$\left(\tilde{\Phi}'_{lp}-\tilde{\Phi}'_{hp}\right)\left(\chi\left(\mu_{hr}^*\right)\tilde{\Phi}'_{hr}-\tilde{\Phi}'_{lr}\right)<\left(\tilde{\Phi}'_{lp}-\chi\left(\mu_{hr}^*\right)\tilde{\Phi}'_{hp}\right)\left(\tilde{\Phi}'_{hr}-\tilde{\Phi}'_{lr}\right),$$

which in turn boils down to:

$$\tilde{\Phi}'_{hr}\tilde{\Phi}'_{lp}<\tilde{\Phi}'_{hp}\tilde{\Phi}'_{lr}. \tag{38}$$

Recall that:

$$\tilde{\Phi}\left(\mu_{hr}^*,\mu_p^*\right)\equiv\Phi\left(\Lambda\left(\mu_{hr}^*\right)-\Lambda\left(\mu_{hp}^*\right)\right), \tag{39}$$

$$\tilde{\Phi}\left(\mu_p^*,\mu_{hr}^*-\ln y\right)\equiv\Phi\left(\Lambda\left(\mu_{lp}^*\right)-\Lambda\left(\mu_{lr}^*\right)\right). \tag{40}$$

Differentiating (39) and (40) yield, respectively:

$$\tilde{\Phi}'_{hr}=\Phi'(\cdot)\,\Lambda'\left(\mu_{hr}^*\right)\ \text{ and }\ \tilde{\Phi}'_{hp}=-\Phi'(\cdot)\,\Lambda'\left(\mu_{hp}^*\right), \tag{41}$$

$$\tilde{\Phi}'_{lp}=\Phi'(\cdot)\,\Lambda'\left(\mu_{lp}^*\right)\ \text{ and }\ \tilde{\Phi}'_{lr}=-\Phi'(\cdot)\,\Lambda'\left(\mu_{hr}^*-\ln y\right). \tag{42}$$

Since $\mu_{hp}^* = \mu_{lp}^* = \mu_p^*$, plugging the expressions in (41) and (42) into (38) leads to the following sufficient condition for (36) to hold:

$$\Lambda'\left(\mu_{hr}^*\right) < \Lambda'\left(\mu_{hr}^* - \ln y\right).$$

Recall that, whenever $\mu > 1$, $\Lambda'(\mu) = \delta^{-1}\left(1-\mu^{-2}\right) > 0$ and $\Lambda''(\mu) = 2\delta^{-1}\mu^{-3} > 0$. Hence, it follows that $\Lambda'\left(\mu_{hr}^*\right) \geq \Lambda'\left(\mu_{hr}^* - \ln y\right)$, leading to a contradiction. Thus, (36) must hold true.

Part (ii). Recall that $\tilde{\Phi}(\cdot)$ is bounded above and below and $\Gamma(1) = 0$. Let $\mu_p^* = 1$ and denote by $\breve{\mu}_R^*$ the level of μ_{hr}^* that makes (30) hold true when $\mu_p^* = 1$. The resulting expression reads:

$$\frac{2}{M} - \tilde{\Phi}\left(1, \breve{\mu}_R^* - \ln y\right) + \frac{2(1-\delta)}{M}\Gamma\left(\breve{\mu}_R^* - \ln y\right) + \chi\left(\breve{\mu}_R^*\right)\left[\tilde{\Phi}\left(\breve{\mu}_R^*, 1\right) + \frac{2(1-\delta)}{M}\Gamma\left(\breve{\mu}_R^*\right) - \frac{\delta}{\rho M}\frac{1}{\breve{\mu}_R^* - 1}\right] = 0,$$

thus it must be the case that $\breve{\mu}_R^* > 1$. Let now $\breve{\mu}_P^*$ denote the value of μ_p^* satisfying (29) when $\mu_{hr}^* = \breve{\mu}_R^*$, and suppose that $\breve{\mu}_P^* = 1$. From (29), it follows that:

$$\tilde{\Phi}\left(1, \breve{\mu}_R^* - \ln y\right) + \frac{2}{M} - \tilde{\Phi}\left(\breve{\mu}_R^*, 1\right) + \frac{2(1-\delta)}{M}\Gamma\left(\breve{\mu}_R^* - \ln y\right) - \frac{\delta}{\rho M}\lim_{\breve{\mu}_P^* \to 1}\left(\frac{1}{\breve{\mu}_P^* - 1}\right) = 0,$$

where the LHS goes to $-\infty$ as $\breve{\mu}_P^* \to 1$. Thus, it must be that $\breve{\mu}_P^* > 1$ for (29) to hold, which implies the P-locus lies above the R-locus for sufficiently low mark-ups.

Part (iii). Recall that $\tilde{\Phi}(\mu, \mu) = 1/M$, and note that $\chi(\infty) = 1$. Furthermore, let $\hat{\Gamma}$ denote the upper-bound of $\Gamma(\mu)$. Firstly, let $\hat{\mu}_R^*$ denote the solution of (30) when $\mu_p^* = \mu_{hr}^* = \hat{\mu}_R^*$, and suppose that $\hat{\mu}_R^* \to \infty$. It follows that:

$$\frac{2}{M} + \frac{4(1-\delta)}{M}\hat{\Gamma} - \frac{\delta}{\rho M}\lim_{\hat{\mu}_R^* \to \infty}\left(\frac{1}{\hat{\mu}_R^* - 1}\right) = 0,$$

where the LHS is strictly positive in the limit. Therefore, it must be that $\hat{\mu}_R^* < \infty$, implying that the R-locus crosses the 45° line. Secondly, let $\hat{\mu}_P^*$ denote the solution of (29) when $\mu_p^* = \mu_{hr}^* = \hat{\mu}_P^*$, and suppose that $\hat{\mu}_P^* = \hat{\mu}_R^*$. From (29), we have:

$$\tilde{\Phi}\left(\hat{\mu}_R^*, \hat{\mu}_R^* - \ln y\right) + \frac{2(1-\delta)}{M}\Gamma\left(\hat{\mu}_R^* - \ln y\right) + \frac{1}{M} + \frac{2(1-\delta)}{M}\Gamma\left(\hat{\mu}_R^*\right) - \frac{\delta}{\rho M}\frac{1}{\hat{\mu}_R^* - 1} = 0. \quad (43)$$

Note from (30) that, in the case $\mu_p^* = \mu_{hr}^* = \hat{\mu}_R^*$, we can write:

$$-\frac{\frac{2}{M} - \tilde{\Phi}\left(\hat{\mu}_R^*, \hat{\mu}_R^* - \ln y\right) + \frac{2(1-\delta)}{M}\Gamma\left(\hat{\mu}_R^* - \ln y\right)}{\chi\left(\hat{\mu}_R^*\right)} = \frac{1}{M} + \frac{2\left(1-\delta\right)}{M}\Gamma\left(\hat{\mu}_R^*\right) - \frac{\delta}{\rho M}\frac{1}{\hat{\mu}_R^* - 1}.$$

Plugging this expression into (43) yields:

$$\chi\left(\hat{\mu}_R^*\right)\tilde{\Phi}\left(\hat{\mu}_R^*, \hat{\mu}_R^* - \ln y\right) - \left(\frac{2}{M} - \tilde{\Phi}\left(\hat{\mu}_R^*, \hat{\mu}_R^* - \ln y\right)\right) + \left(\chi\left(\hat{\mu}_R^*\right) - 1\right)\frac{2\left(1-\delta\right)}{M}\Gamma\left(\hat{\mu}_R^* - \ln y\right) > 0,$$

Therefore, it must be that $\hat{\mu}_P^* < \hat{\mu}_R^*$, implying that the L-locus lies below the R-locus when the latter crosses the $45°$ line.

Bearing in mind all the previous three steps, it follows that there must exist one single combination $\left(\mu_{hr}^*, \mu_p^*\right) \in (1, \infty) \times (1, \infty)$, where also $\mu_{hr}^* > \mu_p^*$, satisfying (29) and (30).

Finally, it must be that $\mu_{lp}^* > \mu_{lr}^*$. To see this, note preliminarily that $\mu_{hr}^* > \mu_{hp}^*$ implies $\tilde{\Phi}\left(\mu_{hr}^*, \mu_{hp}^*\right) > 1/M$, hence from (25) and (26) it follows that $N_{hr}^* > N_{hp}^*$. Now, suppose that $\mu_{lp}^* \leq \mu_{lr}^*$. We have $\tilde{\Phi}\left(\mu_{lp}^*, \mu_{lr}^*\right) \leq 1/M$, which in conjuction with (23) and (24) yields $N_{lp}^* \leq N_{lr}^*$. However, (9) requires that $1/\left(N_{lr}^* + N_{hr}^*\right) \leq \left(1 - N_{hr}^* \ln y\right)\left(N_{lp}^* + N_{hp}^*\right)$, contradicting $N_{lp}^* \leq N_{lr}^*$. □

Proof of Proposition 3. Notice that, since $y_p = 1$ entails $\Lambda_{hp}^* = \Lambda_{lp}^* = \Lambda_p^*$, we may write:

$$S_h^* = \frac{\left(G\left(\Lambda_{hr}^*\right)\right)^\lambda + \left(G\left(\Lambda_p^*\right)\right)^\lambda}{G\left(\Lambda_{hr}^*\right) + G\left(\Lambda_p^*\right) + \left(G\left(\Lambda_{hr}^*\right)\right)^\lambda + \left(G\left(\Lambda_p^*\right)\right)^\lambda}, \tag{44}$$

$$S_l^* = \frac{\left(G\left(\Lambda_{lr}^*\right)\right)^\lambda + \left(G\left(\Lambda_p^*\right)\right)^\lambda}{G\left(\Lambda_{lr}^*\right) + G\left(\Lambda_p^*\right) + \left(G\left(\Lambda_{lr}^*\right)\right)^\lambda + \left(G\left(\Lambda_p^*\right)\right)^\lambda}. \tag{45}$$

Recall that $G\left(\Lambda_{hr}^*\right) > G\left(\Lambda_p^*\right) > G\left(\Lambda_{lr}^*\right)$ since $\Lambda_{hr}^* > \Lambda_p^* > \Lambda_{lr}^*$.

Note that, letting:

$$\Sigma\left(x\right) \equiv \frac{\left(G\left(x\right)\right)^\lambda + \left(G\left(\Lambda_p^*\right)\right)^\lambda}{G\left(x\right) + G\left(\Lambda_p^*\right)}, \tag{46}$$

we may re-express (44)-(45) as:

$$S_h^* = \left[1 + \left(1/\Sigma\left(\Lambda_{hr}^*\right)\right)\right]^{-1},$$
$$S_l^* = \left[1 + \left(1/\Sigma\left(\Lambda_{lr}^*\right)\right)\right]^{-1}.$$

Therefore, proving $S_h^* > S_l^*$ amounts to proving that $\Sigma\left(\Lambda_{hr}^*\right) > \Sigma\left(\Lambda_{lr}^*\right)$. Let thus $\theta_q \equiv G\left(\Lambda_{qr}^*\right)/G\left(\Lambda_p^*\right)$, note that $\theta_h > 1 > \theta_l$. Noting that $G\left(\Lambda_{qr}^*\right) = \theta_q G\left(\Lambda_p^*\right)$, and plugging the relevant expressions into (46) the following condition obtains:

$$\Sigma\left(\Lambda_{hr}^{*}\right) > \Sigma\left(\Lambda_{lr}^{*}\right) \quad \Leftrightarrow \quad \frac{\left(1+\theta_h^{\lambda}\right)}{\left(1+\theta_h\right)} > \frac{\left(1+\theta_l^{\lambda}\right)}{\left(1+\theta_l\right)},$$

which indeed holds true because $\lambda > 1$.

□

Proof of Proposition 4. Recall that $\mathcal{P}_{qy}$ denotes the probability that a market with income level y becomes the initial market of entry of a variety of quality q, and that $\Gamma(\mu_{qy})$ the probability that a variety of quality q undergoes a market expansion towards a given market with income y. Therefore, the probability that a variety with $q = h$ will expand in the next period to a market with the same income as the initial market of entry is given by:

$$\Pr(y_{1st} = y_{2nd} |\, h) = \mathcal{P}_{hr}\,\Gamma(\mu_{hr}^{*}) + \mathcal{P}_{hp}\,\Gamma(\mu_{hp}^{*});$$

whereas the analogous probability for a variety with $q = l$ is:

$$\Pr(y_{1st} = y_{2nd} |\, l) = \mathcal{P}_{lr}\,\Gamma(\mu_{lr}^{*}) + \mathcal{P}_{lp}\,\Gamma(\mu_{lp}^{*}).$$

Bearing now in mind that $\mathcal{P}_{hp} = (2/M) - \mathcal{P}_{hr}$ and $\mathcal{P}_{lp} = (2/M) - \mathcal{P}_{lr}$, we may write:

$$\Pr(y_{1st} = y_{2nd} |\, h) = \mathcal{P}_{hr}\left(\Gamma(\mu_{hr}^{*}) - \Gamma(\mu_{hp}^{*})\right) + \frac{2}{M}\Gamma(\mu_{hp}^{*}) \tag{47}$$

and

$$\Pr(y_{1st} = y_{2nd} |\, l) = \mathcal{P}_{lr}\left(\Gamma(\mu_{lr}^{*}) - \Gamma(\mu_{lp}^{*})\right) + \frac{2}{M}\Gamma(\mu_{lp}^{*}). \tag{48}$$

Lastly, since in equilibrium $\mu_{hp}^{*} = \mu_{lp}^{*} = \mu_{p}^{*} > \mu_{lr}^{*}$, from (47) and (48) it follows that $\Pr(y_{1st} = y_{2nd} |\, h) - \Pr(y_{1st} = y_{2nd} |\, l) = \mathcal{P}_{hr}\left(\Gamma(\mu_{hr}^{*}) - \Gamma(\mu_{p}^{*})\right) + \mathcal{P}_{lr}\left(\Gamma(\mu_{p}^{*}) - \Gamma(\mu_{lr}^{*})\right) > 0.$

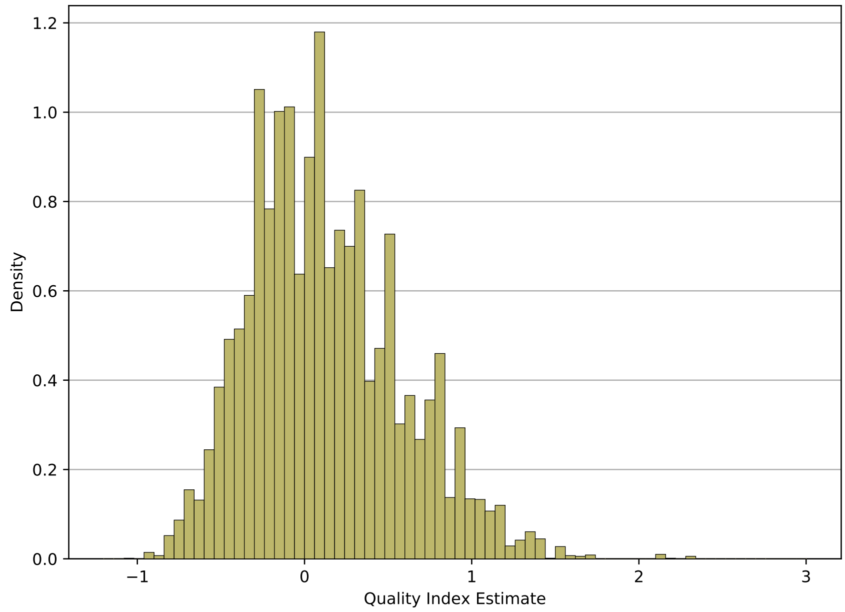
□

Online Appendix (Not Intended for Publication)

B Additional Empirical Results and Robustness Checks

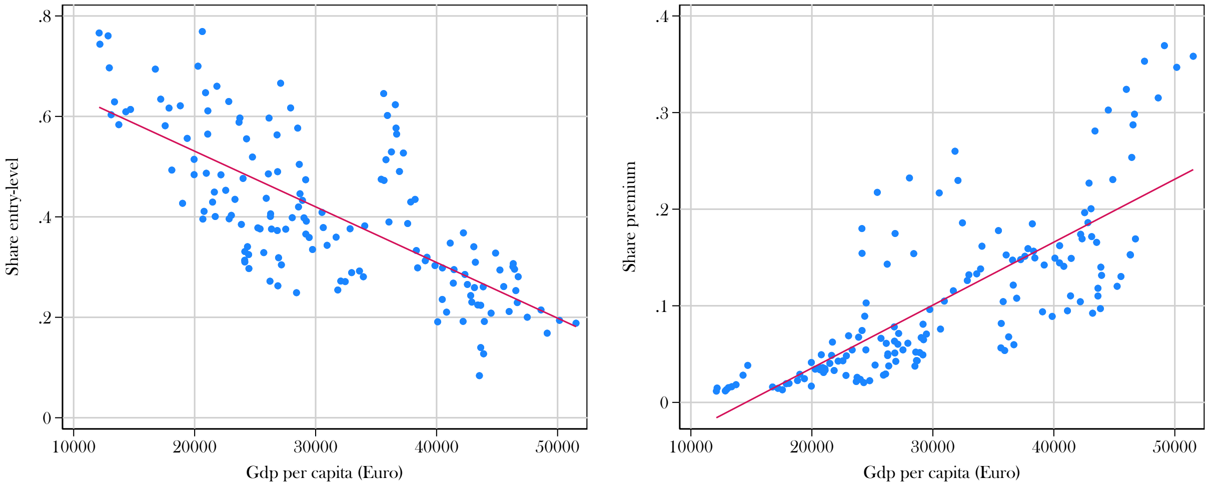
C Additional Data Descriptives

FIGURE C.1. Quality Index Distribution



Notes: Histogram of the estimated quality index for each product in the data based on eq. (2).

FIGURE C.2. Premium and Entry-level Unit-sale-shares by Income per Capita

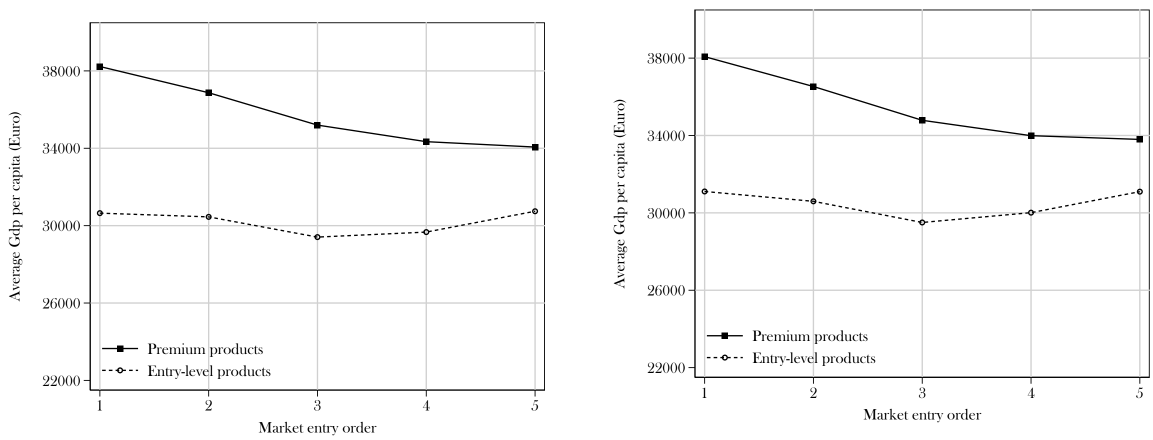


(a) Entry-level

(b) Premium

Notes: The figure plots country-specific yearly shares of the unit sales of entry-level products from total unit sales in (a) and of premium products (unit sales of premium-quality products over total unit sales per year) in (b) vis-a-vis GDP per capita. Entry-level products are those in quantile one, and premium products – in quantile four of the product-specific quality estimates obtained from eq. (2). The lines in both graphs are linear prediction plots.

FIGURE C.3. Order of Market Entry vis-a-vis Income for Products with at Least 5 Destinations



(a) all products sold in at least five markets

(b) all products sold in at least five above- and below-median income countries

Notes: The figure replicates Plots (a) and (b) in Figure 2 in the main text, but reduces the sample only to products with at least 5 sales destinations (1,998 devices). In this figure, therefore, the composition of products per market-entry order is the same. Plot (a) depicts average income per capita by products' order of market entry (first, second, third, etc. market) and quality (premium products (quantile four) shown as solid line, and entry-level products (quantile one) – as dashed line) for all products. Plot (b) depicts the same relationship but pertains to products sold both in above-median and below-median income countries. The order of market entry is determined as per Table C.5. Quality quantiles are based on the full set of products. For comparability, the range of the y-axis is held constant across plots.

TABLE B.1. Quality Index Generation

	Coef. (1)	S.e. (2)
noforst		
yes	0.318***	0.011
doors		
2 doors frz btm	-0.031**	0.012
2 doors frz top	-0.200***	0.016
3+ doors	0.717***	0.049
side by side	0.690***	0.019
energy label		
A+	0.148***	0.010
A++	0.305***	0.013
A+++	0.511***	0.016
B	-0.036	0.029
C	0.183	0.193
brand		
2.b	-0.650***	0.027
3.b	-0.342***	0.039
4.b	-0.204***	0.023
5.b	-0.502***	0.021
6.b	-0.236***	0.039
7.b	-0.741***	0.030
8.b	-0.036*	0.021
9.b	-0.468***	0.023
10.b	-0.160***	0.040
11.b	-0.468***	0.031
12.b	-0.266***	0.022
13.b	-0.113***	0.031
14.b	-0.710***	0.026
15.b	-0.258***	0.035
16.b	1.126***	0.110
17.b	-0.218***	0.023
18.b	-0.709***	0.053
19.b	-0.377***	0.026
20.b	-0.318***	0.028
21.b	-0.467***	0.021
22.b	0.079*	0.046
23.b	-0.599***	0.042
24.b	0.352***	0.045
25.b	-0.245***	0.025
26.b	0.220***	0.026
27.b	0.512***	0.036
28.b	0.191***	0.029
29.b	-0.125***	0.034
30.b	-0.852***	0.033
31.b	-0.331***	0.031
32.b	-0.591***	0.045
33.b	-0.318***	0.025
34.b	-0.347***	0.055
35.b	-0.524***	0.030
36.b	0.004	0.053
37.b	0.041*	0.024
38.b	0.495***	0.055
39.b	-0.503***	0.025
40.b	-0.396***	0.031
41.b	-0.266***	0.021
42.b	-0.419***	0.025
N	926,183	

Notes: The table shows the estimated coefficients from eq. (1) used in the calculation of the product-specific quality index. The excluded type of refrigerator belongs to brand AEG, has an energy class A, no 'nofrost' function, and one door greater than 90 cm. See a detailed description of these variables in Table C.2. Further information on the 41 brands shown in the table is available upon request from the authors. Standard errors are robust and clustered by product. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE B.2. Determinants of First Market Entry: Additional Covariates

	(1)	(2)	(3)	(4)	(5)	(6)
log Income	1.458**	1.565**	1.296**	0.254	1.163	0.373
	(0.646)	(0.763)	(0.640)	(0.752)	(0.815)	(0.978)
ln Income$\times\hat{q}$	1.814***	1.691***	1.924***	1.780***	1.369***	1.425***
	(0.564)	(0.569)	(0.584)	(0.560)	(0.409)	(0.489)
ln Pop		3.492				5.074
		(7.859)				(6.674)
ln Pop$\times\hat{q}$		0.097				0.095
		(0.090)				(0.062)
ln Energy			-0.859			-0.528
			(0.601)			(0.562)
ln Energy$\times\hat{q}$			-0.146			-0.282
			(0.452)			(0.337)
ln Retail				1.721***		1.486***
				(0.516)		(0.535)
ln Retail$\times\hat{q}$				-2.149**		-2.692***
				(0.983)		(0.935)
MS brand					9.655***	9.635***
					(0.994)	(0.978)
MS brand$\times\hat{q}$					-0.120	-0.113
					(1.473)	(1.409)
N	125,088	125,088	125,088	125,088	99,376	99,376

Notes: The method of estimation is conditional logit. The dependent variable equals one for the first market(s) of entry and is set to zero for the remaining countries in a set of 24 possible European destinations. The first market(s) are determined by the earliest date a product appears in any location. All specifications include country fixed effects. The baseline specification without covariates is reported in column (1). ln Income, ln Pop, ln Retail and ln Energy are the natural logarithms of annual GDP per capita (in PPP, Penn World Tables), annual population (Penn World Tables), monthly index of turnover for retail trade (except for motor vehicles and motorcycles) sourced from Eurostat, and half-yearly electricity prices for household consumers, inclusive of all taxes and fees for consumption band from 2 500 kWh to 4 999 kWh, sourced from Eurostat. "MS brand" is a country-date-brand-specific market share. $\hat{q}$ is the product-specific quality index from eq. (1). Standard errors are clustered by brand. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

TABLE B.3. Determinants of Earlier Market Entry: Additional Covariates

	(1)	(2)	(3)	(4)	(5)	(6)
ln Income	4.271***	4.363***	4.288***	4.525***	2.738***	2.837***
	(0.562)	(0.586)	(0.599)	(0.569)	(0.476)	(0.528)
ln Income$\times\hat{q}$	1.535***	1.315***	1.427***	1.497***	1.702***	1.223***
	(0.393)	(0.352)	(0.334)	(0.386)	(0.336)	(0.326)
ln Pop		1.335				4.152**
		(2.704)				(1.894)
ln Pop$\times\hat{q}$		0.196***				0.232***
		(0.066)				(0.088)
ln Energy			1.569***			2.255***
			(0.192)			(0.330)
ln Energy$\times\hat{q}$			0.130			0.270
			(0.193)			(0.248)
ln Retail				-0.121		-0.128
				(0.185)		(0.206)
ln Retail$\times\hat{q}$				-1.032***		-0.236
				(0.373)		(0.458)
MS brand					6.469***	6.297***
					(1.022)	(0.990)
MS brand$\times\hat{q}$					0.283	0.630
					(1.498)	(1.439)
N	125,088	125,088	125,088	125,088	50,352	50,352

Notes: The method of estimation is a ranked-orderd logit. The dependent variable is Rank, which gives the highest value to the first market of entry of product j up to a value of zero for any of the 24 EU markets in the sample, in which product j never enters. See also Table C.5 for further discussion on the construction of the dependent variable. All specifications include country and year fixed effects. For convenience, the baseline specification without additional covariates is shown in column (1). Log Income, log Pop, log Retail and log Energy are the natural logarithms of annual GDP per capita (in PPP, Penn World Tables), annual population (Penn World Tables), monthly index of turnover for retail trade (except for motor vehicles and motorcycles) sourced from Eurostat, and half-yearly electricity prices for household consumers, inclusive of all taxes and fees for consumption band from 2 500 kWh to 4 999 kWh, sourced from Eurostat. "Market share brand" is a country-date-brand-specific market share. "Quality" is the product-specific quality measure from eq. (1. Standard errors are robust and clustered by brand. $^{*}\,p < 0.10$, $^{**}\,p < 0.05$, $^{***}\,p < 0.01$.

TABLE B.4. Role of Income and Quality in Earlier Market Entry within Brand

Brand	ln Income	S.e.	ln Income$\times\hat{q}$	S.e.	Observations
Bosch	4.166***	(0.754)	0.427	(0.337)	8880
Gorenje	6.486***	(1.184)	1.746***	(0.668)	8856
Whirlpool	2.660***	(0.866)	1.147***	(0.256)	8256
Samsung	3.262***	(0.924)	2.407***	(0.350)	7800
Siemens	3.776***	(0.798)	-0.465	(0.446)	7680
Electrolux	1.470**	(0.738)	3.603***	(0.640)	6216
Liebherr	0.606	(0.721)	1.629***	(0.578)	6192
Bauknecht	-0.319	(2.428)	-1.855**	(0.888)	5904
AEG	3.803***	(1.432)	-0.244	(0.663)	5304
Beko	7.217***	(1.071)	1.160***	(0.377)	5040

Notes: The method of estimation is rank-ordered logit. All specifications are based on specification (4) in Table 4. All specifications include country and product fixed effects. All rows are separate regressions where the sample is split by the respective brand. The brand selection in the table reflects the top-10 brands by number of products present in the estimation sample and listed in full in Table C.6 in the Appendix. Standard errors, reported next to estimated coefficients, are clustered by product. $^{*}\,p < 0.10$, $^{**}\,p < 0.05$, $^{***}\,p < 0.01$.

TABLE C.1. Data Coverage

Span	Country
01.2009-09.2013	Belgium, Denmark, Estonia, Finland, France, Greece, Italy, Latvia, Lithuania, Netherlands, Portugal, Slovakia, Spain, Sweden, United Kingdom
01.2009-01.2017	Austria, Croatia, Czech Republic, Germany, Hungary, Poland, Serbia, Slovenia

Notes: The table reports data coverage in month-years per country. On average 86% of all products on the EU market for the period 2009-2013 are present in the 8-country sample whose coverage extends to 2017. The eight countries on average account for 49.6% of total expenditure in the data for 2009-2013.

TABLE C.2. Description of Refrigerators' Characteristics in Main Data

Characteristics	Description or Values
Annual energy use	Annual energy consumption measured in kilowatt hours per year. Mean 272 kWh; s.e. 95.7 kWh
Energy label	A+++ (most efficient) (4.1%); A++ (23.8%); A+ (50.2%); A (21.0%); B (0.86%); C (0.02%)
No-frost system	Yes (35.9%); No (64.1%)
Brand	Liebherr (11.5%); Bosch (9.6%); Whirlpool (8.1%), Gorenje (7.5%); Siemens (7.4%); Electrolux (6.4%), Samsung (5.5%), others (44%)
Number of doors	One door >90cm (20.6%); 2 doors, freezer bottom (56.6%); 2 doors, freezer top (13.1%); 3+ doors (2.2%); side-by-side (7.5%)
Installation	Built-in/built-under (23.2%); freestanding (76.8%)

Notes: The data lists the available refrigerator characteristics in the data. For categorical variables, the percent of each value from total observations is reported in parentheses based on the sample reported in Panel A of Table 1.

TABLE C.3. Description of Variables in Supplemental Data

Variable	Description and Statistics
Energy	Energy prices per kWh (Euro) for household consumers with consumption from 2500-4999 kWh, all taxes and levies included. Frequency: bi-annual. Coverage: h12009-h12017. Variation: Country-by-half-year. Source: Eurostat. Mean: 0.168 s.dev.: 0.054. Min: 0.056 Max: 0.305. N: 408.
Income	GDP per capita (Euro). Frequency: yearly. Coverage 2009-2017. Variation: Country-by-year. Source: Penn World Tables. Mean: 32,316 s.dev.: 9,792. Min: 12,108 Max: 51,524 N: 216.
Pop	Population (in millions). Frequency: yearly. Coverage 2009-2017. Variation: Country-by-year. Source: Penn World Tables. Mean: 20.9 s.dev.: 23.8. Min: 1.31 Max: 82.1 N: 216.
Retail	Index of turnover for retail trade, except for motor vehicles and motorcycles (2010=100). Frequency: Monthly. Coverage: January 2009-January 2017. Variation: Country-by-date(month-year). Source: Eurostat. Mean: 105.1 s.dev.: 15.21. Min: 60.6 Max: 174.8 N: 2,328.
VAT rate	Standard value-added tax rate. Frequency: monthly. Coverage 2009-2017. Variation: Country-by-date. Source: European Commission. Mean: 0.21 s.dev.: 0.026. Min: 0.15 Max: 0.27 N: 2,328.
MS Brand	Ratio of total unit sales of a brand in a given country on a given date to total sales within this country-date. Frequency: monthly. Coverage: January 2009-January 2017. Variation: Brand-by-country-by-date. Source: GfK GmbH. Mean: 0.037 s.dev.: 0.059. Min: 0.00 Max: 0.57 N: 42,963.
Herfindahl-Hirschman Index (HHI)	Mean of sum of MS Brand squared across brands within a country-date. Frequency: monthly. Coverage: January 2009-January 2017. Variation: Country-by-date. Source: GfK GmbH. Mean: 0.14 s.dev.: 0.054. Min: 0.065 Max: 0.39 N: 1,688.

Notes: The table describes the additional variables added to the main GfK data, their frequency, coverage, variation, sources, and basic descriptive statistics, including the number of unique observations (N).

TABLE C.4. Descriptive Statistics: Full Sample

	All		By quality quartile							
			(1)		(2)		(3)		(4)	
	Mean	Mdn	Mean	Mdn	Mean	Mdn	Mean	Mdn	Mean	Mdn
Price	683	542	356	330	517	473	702	640	1,213	1060
	(493)		(129)		(194)		(291)		(677)	
N	926,183		244,258		240,470		224,912		216,543	
Units	35.3		48.09		36.8		31.1		23.9	
	(110.3)		(148.3)		(106.8)		(92.9)		(74.8)	
N	1,041,854		269,724		270,857		253,164		248,109	
Qlty	0.128		-0.379		-0.023		0.282		0.779	
	(0.453)		(0.155)		(0.091)		(0.091)		(0.267)	
N	11,547		3,167		3,233		2,524		2,623	

Notes: The table shows descriptive statistics per product per date per country for the full sample spanning January 2009 to January 2017. The following basic cleaning of the data has been performed: zero or negative prices are replaced with missing observations; negative unit sales are replaced with missing observations. 'Quality' is the time-invariant quality index constructed from the hedonic specification (1). Columns (1)-(4) report statistics for four quantiles of the quality index. 'N' denotes the number of observations. All prices are in Euro.

TABLE C.5. Market Entry and Ranking

Market	First date	Market entry order	Rank	Market entry ties	Rank with with ties
1st Market$_j$	$\tilde{d}_j$	1	24	1	24
2nd Market$_j$	$\tilde{d}_j$+entry_lag$_{12}$	2	23	1	24
3rd Market$_j$	$\tilde{d}_j$ +entry_lag$_{13}$	3	22	2	23
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...
nth Market$_j$	$\tilde{d}_j$ +entry_lag$_{1n}$	n_j	$24 - n_j + 1$	$n_j - \tilde{n}_j$	24- $(n_j - \tilde{n}_j + 1)$
Other markets$_j$	–	–	0	–	0

Notes: The table shows how the market entry sequence of individual products over their life cycle is determined by identifying country-specific first dates. First-date is the first month-year in which product j has non-zero sales in country m. An 'EU-wide' first-date, $\tilde{d}_j$, is defined as the first time product j is introduced anywhere in the EU. entry_lag is the monthly difference between the first and any sequential markets. Thus entry_lag$_{13}$ is the monthly difference of the first dates in the first and third markets of entry. The series of country-specific first dates directly translates into market-entry order. We construct the Rank variable by assigning a value of 24 to the first market(s) reflecting the total number of countries in the data, 23 to the second, and so on until the last market of entry, which is given a rank of $24 - n_j + 1$. In many instances, products enter several markets simultaneously. In the example shown in the fifth column, the 1st and 2nd markets are contemporaneous such that entry_lag$_{12} = 0$. In this case, the market entry order is the same, and so are the assigned ranks. The total number of markets n_j for products with tied entry are therefore adjusted down by the number of markets with tied entry $\tilde{n}_j$. For example, if four countries are entered as third markets, then this tie has three duplicates. The assumption is that firms value ties equally. Other markets$_j$ are those markets out of the 24, in which product j is never sold. All of these markets are assigned a rank of zero.

C.1 Market presence by annual cohorts and product's average life-cycles

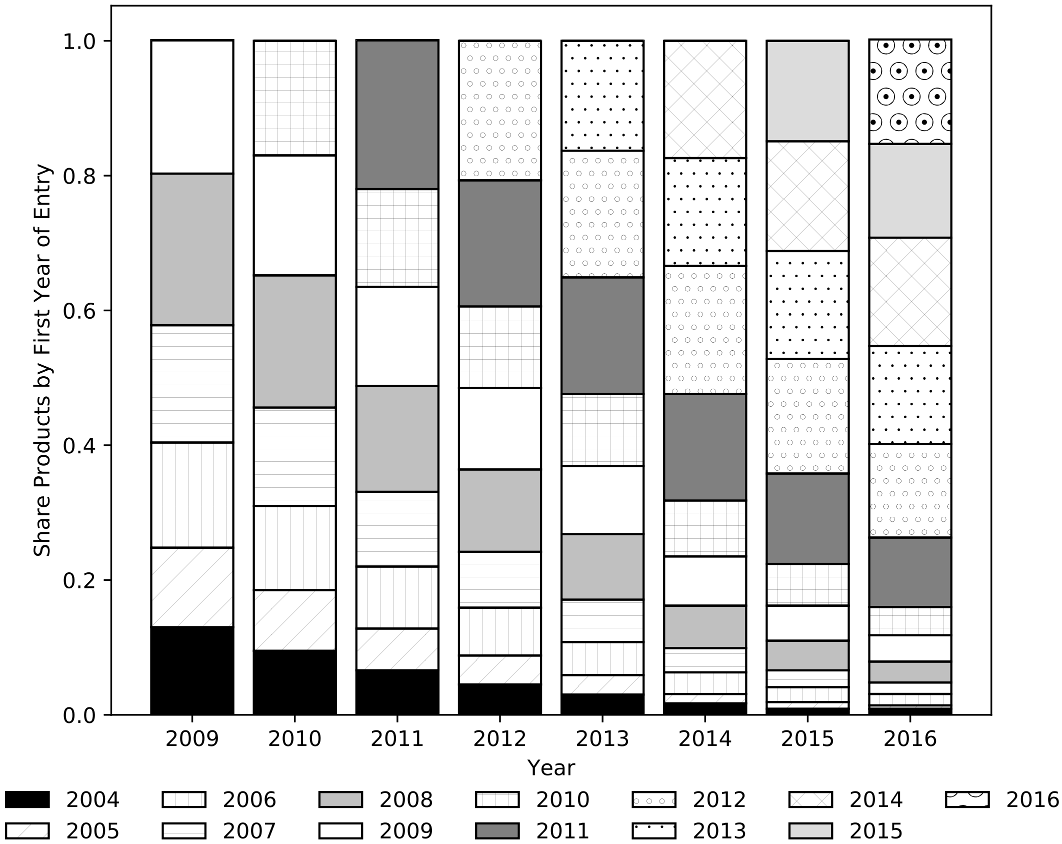
Figure C.4 reveals the annual-cohort-specific market composition as separate annual-cohorts' shares (based on EU-wide entry years, which we observe even for already existing products in 2009 when the data starts) from the total number of products on offer in a given year.

Focusing on 2009, the figure reveals that appliances in that year are a mixture of annual cohorts 2004-2009, with the share of newly introduced products amounting to 19.8%. The top sub-bar on each bar indicates that throughout 2009-2016, the annual share of new market entrants remains stable at close to 20%.

To understand the cohort-specific extent of market misidentification in the generation of market sequences, we need a reasonably accurate measure of average life cycles. While it is difficult to provide descriptive statistics on the average product life-span given the more limited country coverage from 2014 onwards and the end of the data set in January 2017, based on annual-cohort 2009, which has the longest presence in multiple markets, products remain within a country for on average 3.75 years (s.e. 1.25 years), and EU-wide – for 5.5 years. Conducting the same exercise with the sub-sample of eight countries spanning 2009-2017, the country-specific life-cycle is 3.48 years (s.e 2.15), and the sub-sample-wide – 5.57 (2.29 years), both values very close to the ones obtained with the 2009-annual-cohort alone.

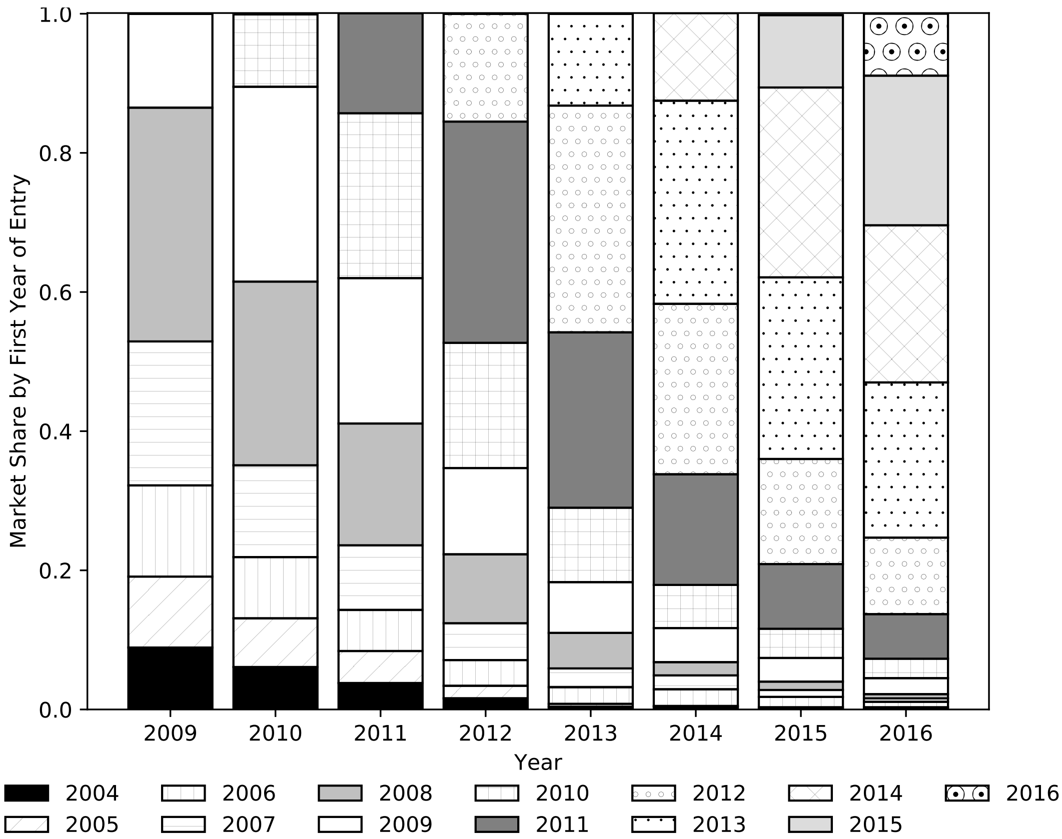
Despite the presence of multiple annual cohorts per year as indicated in Figure C.4, Figure C.5 shows that in terms of sales, invariably the four newest annual cohorts account for more than 80% of the market share per year, such that with respect to meaningful market shares, EU life-spans appear to not exceed 4 years. Given that country coverage in the data is close to complete for the EU in the period 2009-2013, a global life-cycle of about 4 years would indicate that market sequences are most accurately recovered for annual cohorts 2009-2010 and least accurately for cohort 2013. For annual cohort 2013 only the first market of entry is ensured to be correctly identified as the data's country coverage reduces to 8 countries in 2014. Thus, the second market of entry in the data for this cohort will not necessarily match the actual second market of entry, which may not be in the data.

FIGURE C.4. Product composition by annual-cohorts



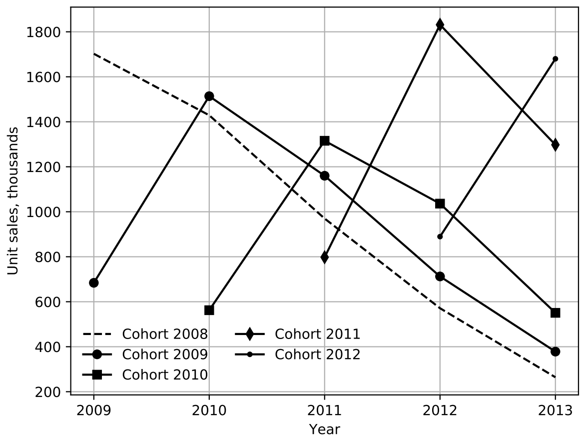
Notes: The bar chart shows the share of products by cohorts of first-year of market entry within a year, spanning 2009-2016. Thus, in 2009, the share of products that entered the EU market in 2005 and are still sold in 2009 is 0.118, those that entered in 2006 – 0.156, 2007 – 0.174, 2008 – 0.225, and newly introduced products in 2009 account for 0.198 of all products on the market in that year. Until 2013, the total number of products and cohort-specific shares are based on 24 countries, and from 2014 onwards – on 8 EU countries. First-year of market entry is the first year in which a product appears on the EU market anywhere. The first year is truncated at 2004, such that the shares of products over time that enter the market in 2004 are likely also capturing products introduced before 2004. Within each bar, sub-bars are stacked in such a way that the share of new market entrants in year y is always on top, followed immediately by cohort $y-1, y-2$, etc.

FIGURE C.5. Market share composition by annual-cohorts

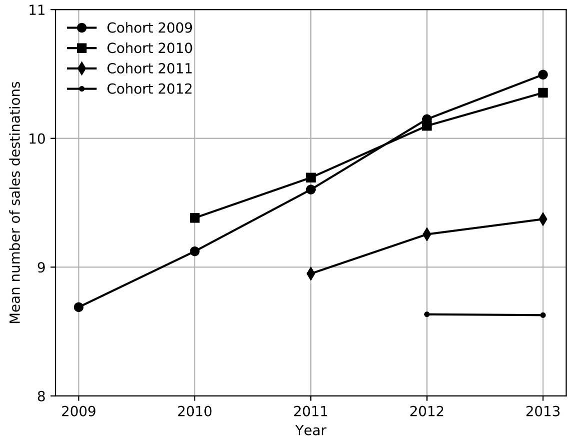


Notes: The bar chart shows the market share by cohorts of first-year of market entry within a year, spanning 2009-2016. Thus, in 2009, the market share of products that entered the EU market in 2005 and are still sold in 2009 is 0.10, those that entered in 2006 – 0.13, 2007 – 0.21, 2008 – 0.34, and newly introduced products in 2009 account for 0.14 of all unit sales on the market in that year. Until 2013, unit sales and cohort-specific market shares are based on 24 EU countries, and from 2014 onwards – on 8 EU countries. First-year of market entry is the first year in which a product appears on the EU market anywhere. The first year is truncated at 2004, such that the market share of products over time that enter the market in 2004 is likely also capturing that of products introduced prior to 2004. Within each bar, sub-bars are stacked in such a way that the market share of new market entrants in year y is always on top, followed immediately by the market share of cohort $y-1, y-2$, etc.

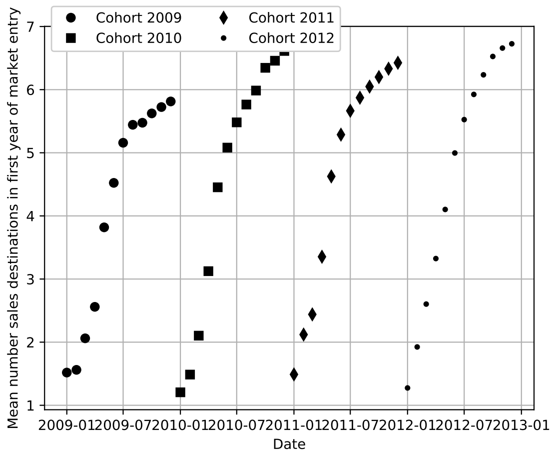
FIGURE C.6. Cohort-specific Sales and Sales Destinations



(a) aggregate unit sales over life-cycle



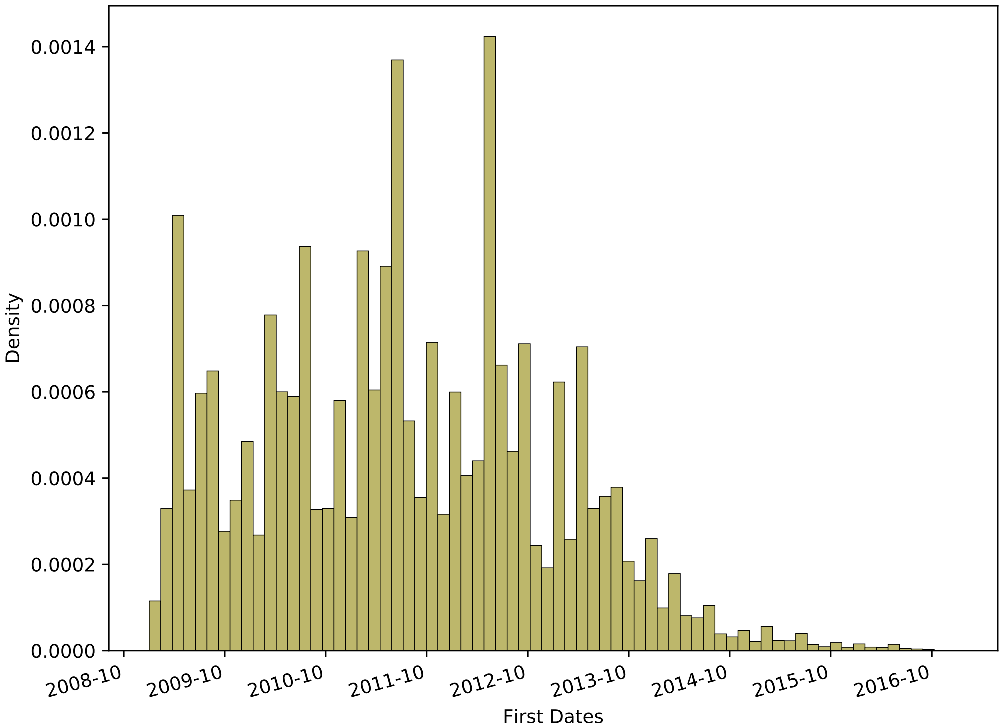
(b) sales destinations over life-cycle



(c) sales destinations by date within first year

Notes: Plot (a) shows yearly sales aggregated across 24 countries (sales destinations) by cohort of products entering in 2009, 2010, 2011, or 2012 over the period 2009-2013 due to different country coverage from 2014 onward (see Table C.1). Plot (b) shows the cohort-specific average number of sales destinations by year for the same period. Plot (c) focuses solely on sale-destination-entry by cohort by date within the *first* year of market entry.

FIGURE C.7. Country-specific Entry Dates



Notes: The figure plots the country-specific first dates (month-year combination) of a product's entry in a given market. These are determined by finding a) the first year, in which a product appears in a given country, and b) the first month within the first year, in which units sold are not missing and not zero. The plot pertains to all products with 'global' first dates between 2009-2013. First dates plotted for 2014-2016 therefore capture such products' first dates in the second, third, etc. markets.

TABLE C.6. Brands' Coverage and 2009-2013 Manufacturing Locations in Europe

Brand	No. Products	Production Locations in Europe
Tradebrand	502	–
Bosch	370	Germany, Greece, Spain
Gorenje	369	Serbia, Slovenia
Whirlpool	344	Italy, Poland
Samsung	325	Poland
Siemens	320	Germany, Spain
Electrolux	259	Hungary, Italy, Sweden
Liebherr	258	Austria, Bulgaria, Germany
Bauknecht	246	Italy, Poland
AEG	221	Hungary, Italy
Beko	210	Romania
LG	208	Poland in and after 2011
Hotpoint-Ariston	148	Italy, Poland
Zanussi	127	Hungary, Italy, Sweden
Indesit	119	Italy, Poland
Candy	111	Czech Republic
Exquisit	99	–
Miele	91	Austria, Bulgaria, Germany
Neff	84	Germany, Spain
Sharp	76	No production in Europe
Amica	67	Poland
Smeg	67	Italy
Privileg	61	Hungary, Italy, Poland
Schaub Lorenz	48	No production in Europe
Elektra Bregenz	47	Romania
Daewoo	41	No production in Europe
Quadro	35	No production in Europe
Bomann	34	No production in Europe
Fagor	34	Italy, Poland, Spain
Haier	34	Italy
Panasonic	33	No production in Europe
Gaggenau	28	France, Germany
PKM	28	No production in Europe
Blomberg	27	Romania
Hoover	27	Czech Republic
Kueppersbusch	27	Austria, Germany
Severin	24	No production in Europe
Koncar	21	No production in Europe
Constructa	20	Germany
Snaige	14	Lithuania
Juno-Electrolux	8	Hungary, Italy

Notes: The table lists the brands present in the estimation sample used in Sections 5 and 6 in the main text, the number of products associated with each brand in the sample as well as the respective European manufacturing locations throughout the period 2009-2013. "Tradebrand" denotes any retailer brand. Consequently, retailer brands cannot be differentiated in the data. Source: The search of production locations was carried out by the authors assisted by ChatGPT 5.0 as a research tool.

C.2 Refrigerator Industry Manufacturing Locations in Europe

Table C.6 lists in the first column the brands present in our dataset, alongside the total number of different products (fridge models) offered by each of them during the years 2009-2013 in the second column. In the third column, the table reports the different locations (countries) of manufacturing for refrigerators by each of the brands within Europe, also during the years 2009-2013.

The information in Table C.6 supports some robustness checks presented in Table 4 and in Table 5. Specifically, we rely on the European production locations of each brand to construct a sub-sample of products for which we can be certain that their first market of entry differs from the country where it was manufactured:

- *Subsample of products whose first-market of entry is not the country of manufacturing*: In specifications (3) and (5) of Table 4 and in specifications (4) and (8) of Table 5, we exclude refrigerator models whose first market of entry could plausibly also be the country where that model's brand manufactures refrigerators. we exclude refrigerator models for which the first market of entry could plausibly also be the country of manufacture. Specifically, we retain only models whose first entry market does not overlap with any country where their respective brand operates a refrigerator manufacturing plant. For example, for Bosch, we exclude all products first introduced in Germany, Greece, or Spain. This restriction is deliberately conservative: a Bosch model manufactured in Greece but first launched in Germany would still be excluded. Because we cannot observe the precise manufacturing location of each product, we remove all cases where the country of manufacture might coincide with the first market of entry.

In terms of the size of the above sub-sample, amongst the total number of 5,212 refrigerators models introduced during 2009-2013, there are 3,485 models (66.9%) that are also present in the 'subsample of products whose first-market of entry is not the country of manufacturing'.

D Omitted Proofs

Definition 1. *Let* $M_q \equiv \left(\int_{\mathcal{J}_q} \ln \mu_j \, dj\right) / N_q$, *for* $q = l, h$.

Lemma 2. *A Nash equilibrium features symmetry in the mark-ups of varieties within quality layers; that is,* $\mu_j^* = \mu_q^*$ *for all* $j \in \mathcal{J}_q$ *and* $q = l, h$. *Furthermore, it is always unique and features* $\mu_j^* > 1$ *for all* j.

Proof. Using Definition 1, we may rewrite (8) as:

$$\mu_j + \ln \mu_j = 1 + (q - \Gamma) \ln y + \frac{1}{N} + M_q, \tag{C.49}$$

where we have exploited $\left(\int_{k \neq j} \ln \mu_k \, dk\right) / N_q = M_q$. The symmetry of mark-ups then immediately follows from noticing that the sum $\mu_j^* + \ln \mu_j^*$ in the LHS of (C.49), written for the optimal mark-up μ_j^*, is strictly increasing in μ_j^*, while the RHS of (C.49), $1 + (q - \Gamma) \ln y + 1/N + M_q^*$, is constant for a given level of quality $q = l, h$.

Consider now the definition $\mu_j \equiv \varepsilon_j / (\varepsilon_j - 1)$ jointly with (7). It follows that $\mu_j > 1$ whenever $D_j > 0$ (i.e., for all firms in the market). As a consequence, there cannot be a Nash equilibrium with $M_q^* = 0$, as this would immediately imply $\mu_j^* = 1$ for all j. Next, notice from (C.49) that since the best-response functions $\mu_j(M_q)$ are such that $\partial \mu_j / \partial M_q > 0$, a sufficient condition for the existence of a unique equilibrium where all $1 < \mu_j^* < \infty$ for all $j \in \mathcal{J}_q$ will be:

$$\frac{\partial \ln \mu_j}{\partial M_q} < 1 \text{ and } \frac{\partial^2 \ln \mu_j}{(\partial M_q)^2} < 0 \text{ for all } M_q > 0. \tag{C.50}$$

Differentiating the best-response functions $\mu_j(M_q)$ in (8) with respect to M_q and rearranging yields:

$$\frac{\partial \ln \mu_j}{\partial M_q} = \frac{1}{1 + \mu_j}, \tag{C.51}$$

and the expression in (C.51) straightforwardly implies that both conditions in (C.50) hold true. □

Proof of Proposition 1. Recall Definition 1, and notice that from Lemma 2 it immediately follows that $M_q^* \equiv \left(\int_{\mathcal{J}_q} \ln \mu_q^* \, dk_q\right) / N_q = \ln \mu_q^*$, with $q = l, h$. We can thus write down the conditions for the Nash equilibrium stemming from (C.49) as follows:

$$\mu_l^* = 1 + 1/N + (l - \Gamma) \ln y \text{ and } \mu_h^* = 1 + 1/N + (h - \Gamma) \ln y,$$

from where (9) and (10) obtain after plugging $\Gamma = (N_l l + N_h h) / N$ in the above expressions, and letting $h - l = 1$. □

Lemma 3. *Let* $\Delta_{qy} \equiv \Lambda_{qy} - \Lambda_{qy'}$, *with* $y' \neq y$, *where* $\Lambda_{qy} = \delta^{-1} (\mu_{qy} - 1)^2 / \mu_{qy}$. *Then* $\mathcal{P}_{qy} = \Phi(\Delta_{qy})$, *where* $\Phi(\Delta_{qy})$ *is an increasing function of* Δ_{qy} *and* $\Phi(0) = 1/M$.

Proof. Bearing in mind (11), we can observe that for a generic country m with real per-capita income y and a generic newly designed variety $j \in \mathcal{J}_q$, we have that the expected value of the intertemporal stream of profit net of the entry cost in market m is given by:

$$\Pi_{jy} = \Lambda_{qy} - \phi_{jm}. \tag{C.52}$$

Consider a pair of generic countries m' and m'' with income y and $y' \neq y$, respectively. Using (C.52), it follows that variety j is introduced first in m if the following two conditions hold simultaneously:

$$\phi_{jm} < \phi_{jm'}, \text{ for all } m' \neq m, \tag{C.53}$$
$$\phi_{jm} < \phi_{jm''} + \Delta_{qy}, \text{ for all } m''. \tag{C.54}$$

Note that, if $\Delta_{qy} < 0$, there exist a subset of values of ϕ_{jm} for which variety j is not introduced first in m, while if $\Delta_{qy} > 0$, there exist a subset of values of ϕ_{jm} for which variety j is not introduced first in any m''. Hence, letting $\tilde{\phi}_b \equiv \max\left\{\underline{\phi}, \underline{\phi} + \Delta_{qy}\right\}$ and $\tilde{\phi}_a \equiv \min\left\{\overline{\phi} + \Delta_{qy}, \overline{\phi}\right\}$, and provided that $\underline{\phi} - \overline{\phi} < \Delta_{qy} < \overline{\phi} - \underline{\phi}$, from the set of conditions (C.53) and (C.54), the probability that the newly designed variety of quality q will be introduced first in a market with income y is given by:

$$\mathcal{P}_{qy} = \int_{\underline{\phi}}^{\tilde{\phi}_b} \left(1 - F\left(\phi_j\right)\right)^{\frac{M}{2}-1} f\left(\phi_j\right) d\phi_j$$
$$+ \int_{\tilde{\phi}_b}^{\tilde{\phi}_a} \left(1 - F\left(\phi_j\right)\right)^{\frac{M}{2}-1} \left(1 - F\left(\phi_j - \Delta_{qy}\right)\right)^{\frac{M}{2}} f\left(\phi_j\right) d\phi_j, \tag{C.55}$$

where $f\left(\cdot\right)$ denotes the pdf function associated to $F\left(\cdot\right)$. From (C.55) we can observe that this probability is a function of Δ_{qy}. We can thus write:

$$\mathcal{P}_{qy} = \Phi(\Delta_{qy}).$$

Notice that $\Phi\left(0\right) = 1/M$. In addition, when $\Delta_{qy} > 0$ and $\Delta_{qy} < \overline{\phi} - \underline{\phi}$ we have $\partial\mathcal{P}_{qy}/\partial\Delta_{qy} > 0$, while when $\Delta_{qy} < 0$ and $\Delta_{qy} > \underline{\phi} - \overline{\phi}$ we also have $\partial\mathcal{P}_{qy}/\partial\Delta_{qy} > 0$.[43] □

Proof of Lemma 1. Consider a generic country $m \in \mathcal{W}$ with income y. The sets of country m's neighbouring and nearby markets are $\{m_{0p}, m_{0r}\}$ and $\{m_{1p}, m_{1r}\}$, repsectively. Bearing in mind Assumption 4 coupled with (12), it follows that, along the steady state, m will be receiving as secondary market expansions a mass of varieties of quality q equal to

[43] In particular, when $\Delta_{qy} > 0$ and $\Delta_{qy} < \overline{\phi} - \underline{\phi}$

$$\frac{\partial\mathcal{P}_{qy}}{\partial\Delta_{qy}} = \int_{\underline{\phi}+\Delta_{qy}}^{\overline{\phi}} \frac{M}{2}\left(1 - F\left(\phi_j\right)\right)^{\frac{M}{2}-1} \left(1 - F\left(\phi_j - \Delta_{qy}\right)\right)^{\frac{M}{2}-1} f\left(\phi_j - \Delta_{qy}\right) f\left(\phi_j\right) d\phi_j,$$

whereas when $\Delta_{qy} < 0$ and $\Delta_{qy} > \underline{\phi} - \overline{\phi}$

$$\frac{\partial\mathcal{P}_{qy}}{\partial\Delta_{qy}} = \int_{\underline{\phi}}^{\overline{\phi}+\Delta_{qy}} \frac{M}{2}\left(1 - F\left(\phi_j\right)\right)^{\frac{M}{2}-1} \left(1 - F\left(\phi_j - \Delta_{qy}\right)\right)^{\frac{M}{2}-1} f\left(\phi_j - \Delta_{qy}\right) f\left(\phi_j\right) d\phi_j.$$

$\left[G\left(\Lambda_{yq}^{*}\right)+\left(G\left(\Lambda_{yq}^{*}\right)\right)^{\lambda}\right]\left(\mathcal{P}_{qy}+\mathcal{P}_{qy'}\right)\rho M$, with $y'\neq y$. Hence, since there are $M/2$ richer and $M/2$ poorer markets in $\mathcal{W}$, it follows that the total number of market expansions of varieties of quality q along the steady state in $\mathcal{W}$ is equal to:

$$\left\{\left[G\left(\Lambda_{qr}^{*}\right)+\left(G\left(\Lambda_{qr}^{*}\right)\right)^{\lambda}\right]+\left[G\left(\Lambda_{qp}^{*}\right)+\left(G\left(\Lambda_{qp}^{*}\right)\right)^{\lambda}\right]\right\}\left(\mathcal{P}_{qr}+\mathcal{P}_{qp}\right)\rho M\times\frac{M}{2}. \tag{C.56}$$

Similarly, it follows that the total number of expansions (considering the whole world economy) to nearby (non-neighbouring) markets along the steady state is equal to:

$$\left[\left(G\left(\Lambda_{qr}^{*}\right)\right)^{\lambda}+\left(G\left(\Lambda_{qp}^{*}\right)\right)^{\lambda}\right]\left(\mathcal{P}_{qr}+\mathcal{P}_{qp}\right)\rho M\times\frac{M}{2}. \tag{C.57}$$

Therefore, dividing (C.57) by (C.56) the result in (15) obtains. □

E Numerical analysis

Entry costs We let the first-market entry cost be drawn from the distribution $U\left[0,\overline{\phi}\right]$. Since all markets with income y offer the producers the same expected profit (gross of first-entry cost), the first-entry market candidate with income y is the market with the lowest (first-market) entry cost draw. Let $\phi_{jy}=\min_{m\in y}\left\{\phi_{jm}\right\}$. For a given x, we can write

$$\tilde{F}\left(x\right)=P\left(\phi_{jy}\leq x\right)=1-P\left(\phi_{jy}>x\right)=1-P\left(\min_{m\in y}\left\{\phi_{jm}\right\}>x\right).$$

Note that $\min_{m\in y}\left\{\phi_{jm}\right\}>x$ requires $\phi_{jm}>x$ for all $m\in y$. Since the draws are iid and the number of markets is the same for each income level y, we have

$$\tilde{F}\left(x\right)=1-\prod_{m\in y}P\left(\phi_{jm}>x\right)=1-P\left(\phi_{jm}>x\right)^{M/2}.$$

Keeping in mind the distribution of the draws, this yields

$$\tilde{F}\left(x\right)=1-\left[\left(\overline{\phi}-x\right)/\overline{\phi}\right]^{M/2}=1-\left(1-x/\overline{\phi}\right)^{M/2}.$$

Therefore, we can sample the lowest first-market entry cost draw for each y as $\phi_{jy}=\overline{\phi}X$, where $X\sim Beta\left(1,M/2\right)$, since by definition X has CDF $1-\left(1-X\right)^{M/2}$. As we show below, the probability of first entry in a market with income y is then obtained by comparing the expected profits of markets in different subsets, y and $y'\neq y$. This is computed numerically using a Monte Carlo routine based on a large number D of draws.

We let the probability distribution governing the expansion-market entry cost be $U\left[0,\overline{\varphi}\right]$.

Mark-ups We let the mark-up depend explicitly on the quality level differential between models of different type. Accordingly, we may write the mark-ups for models of low (l) and high (h) quality in any market with income y respectively as

$$\begin{aligned}\mu_{ly}&=1+\frac{1}{N_{ly}+N_{hy}}-\frac{N_{hy}}{N_{ly}+N_{hy}}\left(h-l\right)\ln y,\\ \mu_{hy}&=\mu_{ly}+\left(h-l\right)\ln y.\end{aligned}$$

Stream of profits We let the stream of profits before entry depend explicitly on the nominal aggregate income. Accordingly, for any model of quality q and market with income y, we may write[44]

$$\Lambda_{qy} = \frac{1}{\delta}\frac{[\max(0, \mu_{qy} - 1)]^2}{\mu_{qy}}\Upsilon_y$$

Probability of positive expansion profit The probability of a positive expansion net profit stream for a model of quality q with a first-entry market with income y to a neighboring expansion market with income y' is

$$G_{qyy'} = \frac{\min(\Lambda_{qy'}, \overline{\varphi})}{\overline{\varphi}}.$$

Expected number of expansion markets The expected number of expansion markets for a model of quality q with a first-entry market with income y to neighboring and non-neighboring markets with income y' is

$$\Gamma_{qyy'} = G_{qyy'} \cdot \theta_{yy'} + (G_{qyy'})^{\lambda} \cdot \vartheta_{yy'}.$$

Expected expansion net profit stream The expected expansion net profit stream for a model of quality q in a market with income y' is given by

$$\Pi_{qy'}(\lambda_\nu) = \overline{\varphi}\left[\frac{1}{\lambda_\nu + 1}\min\left(\frac{\Lambda_{qy'}^{\lambda_\nu+1}}{\overline{\varphi}^{\lambda_\nu+1}}, 1\right) + \max(0, \Lambda_{qy'} - \overline{\varphi})\right],$$

where $\lambda_\nu = 1$ for neighboring markets and $\lambda_\nu = \lambda$ for non-neighboring markets. This expression encompasses the cases:

1. $\Lambda_{qy'} \leq \overline{\varphi}$, which yields $\Pi_{qy'}|_{\Lambda_{qy'} \leq \overline{\varphi}} = \int_0^{\Lambda_{qy'}} (\Lambda_{qy'} - \varphi)\, g_\nu(\varphi)\, d\varphi = \left[(\lambda_\nu + 1)\overline{\varphi}^{\lambda_\nu}\right]^{-1} \Lambda_{qy'}^{\lambda_\nu+1}$;

2. $\Lambda_{w'q} > \overline{\varphi}$, which yields $\Pi_{qy'}|_{\Lambda_{qy'} > \overline{\varphi}} = \overline{\varphi}\left[(\lambda_\nu + 1)^{-1} + \Lambda_{qy'} - \overline{\varphi}\right]$,

   where $g_\nu(\varphi)$ is the pdf of $G(\varphi)$ for neighboring markets and of $(G(\varphi))^{\lambda}$ for non-neighboring markets.

The expected expansion net profit stream for a model of quality q with a first-entry market with income y accruing from expanding to neighboring and non-neighboring markets with income y' is

$$\Omega_{qyy'} = \Pi_{qy'}(1) \cdot \theta_{yy'} + \Pi_{qy'}(\lambda) \cdot \vartheta_{yy'}.$$

[44] Markups such that $\mu_{qy} < 1$ will drive producers off the market. We therefore replace $(\mu_{qy} - 1)^2$ with $[\max(0, \mu_{qy} - 1)]^2$ since using the first expression would result in spurious positive values of Λ_{qy}.

Expected total expansion net profit stream The total value of the expected expansion net profit stream for a model of quality q with a first-entry market with income y is given by

$$\Pi^e_{qy} = \sum\nolimits_{y'} \Omega_{qyy'}.$$

Conditional expected total net profit stream Conditional on ϕ_{jy}, the total net profit stream for a model j of quality q potentially accruing from entering first in a market with income y is given by

$$\Pi^j_{qy} = \Lambda_{qy} - \phi_{jy} + \Pi^e_{qy}.$$

Conditional first entry indicator The producer of a model j of quality q will choose the largest total net profit stream accruing from entering first in a market with income y, with entry cost ϕ_{jy}, or $y' \neq y$, with $\phi_{jy'}$. In case of a tie, the producers will equally split across markets in the two subsets. Accordingly, we define the indicator (where $s = \{\phi_{jy}, \phi_{jy'}\}$ stands for state of nature)

$$I_{qys} = \begin{cases} 0 & \text{if } \Pi^j_{qy} - \Pi^j_{qy'} < 0, \\ 0.5 & \text{if } \Pi^j_{qy} - \Pi^j_{qy'} = 0, \\ 1 & \text{if } \Pi^j_{qy} - \Pi^j_{qy'} > 0. \end{cases}$$

First entry probability The probability of entering first on a market with income y for a model of quality q is the ratio between the total count of conditional first entry in a markets with income y (positive I_{qys}) and the total number of draws D. Formally,

$$\mathcal{P}_{qy} = \frac{1}{D} \sum_{s=1}^{D} I_{qys}.$$

Equilibrium conditions The equilibrium condition for a market with income y and model of quality q is given by

$$eq_{qy} : \mathcal{P}_{qy} + (1-\delta)\,\mathcal{P}_{qy}\Gamma_{qyy} + (1-\delta)\,\mathcal{P}_{qy'}\Gamma_{qyy'} - \frac{\delta}{2\rho} N_{qy} = 0.$$

Calibration

There are ten (sets of) figures (parameters/exogenous variables) to feed to the code, namely y_r, Υ_r, $\{\theta_{yy'}\}$, $\{\vartheta_{yy'}\}$, $h - l$, δ, ρ, $\overline{\phi}$, $\overline{\varphi}$, and λ. A pair of scaling parameters, ρ and $\overline{\phi}$, take values 1 and 0.2 and set a benchmark for the number of models and the entry cost, respectively. Another pair, $\overline{\varphi}$ and λ, cannot be directly matched to the data, thus we use the model to deliver predictions that can be matched to observed figures and are informative regarding the remaining two parameters under consideration. The two targets we select are as follows:

1. Fraction of models that do expand to further markets (after their first entry);
2. Fraction of non-neighboring expansion markets (out of the total count of expansions).

The model delivers predictions regarding these targets as follows:

1. Recall that the probability of a positive expansion net profit stream of a model of quality q with a first-entry market with income y to a neighboring market with income y' is $G_{qyy'}$. The value $1-G_{qyy'}$ then measures the probability of not expanding to that market. The probability of not expanding in any neighboring market with income y' is $(1-G_{qyy'})^{\theta_{yy'}}$, and $(1-G_{qyy'})^{\theta_{yy'}}\left[1-(G_{qyy'})^{\lambda}\right]^{\vartheta_{yy'}}$ the probability of not expanding in any neighboring or non-neighboring markets with income y'. The probability of expanding to no market is $\prod_{y'}(1-G_{qyy'})^{\theta_{yy'}}\left[1-(G_{qyy'})^{\lambda}\right]^{\vartheta_{yy'}}$. The probability of expanding to at least one market is therefore $1-\prod_{y'}(1-G_{qyy'})^{\theta_{yy'}}\left[1-(G_{qyy'})^{\lambda}\right]^{\vartheta_{yy'}}$. The average probability of a positive expansion for a generic model across every combination of market subsets thus reads
$$\bar{G}=\frac{1}{4}\sum\nolimits_{q}\sum\nolimits_{y}\left[1-\prod\nolimits_{y'}(1-G_{qyy'})^{\theta_{yy'}}\left[1-(G_{qyy'})^{\lambda}\right]^{\vartheta_{yy'}}\right].$$

2. Recall that the expected number of expansion markets of a model of quality q with a first-entry market with income y to neighboring and non-neighboring markets with income y' is $\Gamma_{qyy'}=\Gamma_{qyy'}=G_{qyy'}\cdot\theta_{yy'}+(G_{qyy'})^{\lambda}\cdot\vartheta_{yy'}$. Then, the share of non-neighboring expansions relative to the total number of expansions is given by $(G_{qyy'})^{\lambda}\cdot\vartheta_{yy'}/\Gamma_{qyy'}$. The average relative share of non-neighboring market expansions for a generic model across every combination of market subsets thus reads
$$\bar{S}=\frac{1}{8}\sum\nolimits_{q}\sum\nolimits_{y}\sum\nolimits_{y'}\frac{(G_{qyy'})^{\lambda}\,\vartheta_{yy'}}{\Gamma_{qyy'}}.$$

Figure 5 isolates the contribution of the two simplifying assumptions that were relaxed in the calibrated version. Starting from the full calibration, we successively impose:

- Equal market size –all destinations have identical nominal expenditure ($\Upsilon_r=1$).
- No agglomeration –each market faces the average calibrated number of neighbors, independent of income($\theta_{yy'}=1.395$);
- Baseline benchmark –a version that combines equal size and uniform neighborhood structure($\Upsilon_r=1,\ \theta_{yy'}=1.395$).

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