

# Intensive and Extensive Margins of Iran's Horticultural Exports: A Gravity Approach

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## Abstract

This study analyzes the factors influencing Iran's horticultural exports from 2001 to 2023, focusing on market characteristics, trade costs, regional trade agreements, and external economic shocks. Utilizing a gravity framework combined with the two-stage Helpman–Melitz–Rubinstein (HMR) approach, the study distinguishes between the extensive margin (market entry probability) and the intensive margin (export values). Key findings reveal that higher per capita income and larger populations in destination countries positively impact both margins, while increased geographical distance adversely affects both margins. Furthermore, development gaps specifically hinder the extensive margin by limiting market entry. Additionally, economic sanctions and the global financial crisis hinder the extensive margin, affecting new market access, while showing a marginally significant positive association with deeper exports within existing relationships. Regional trade agreements particularly bolster both margins in Asian markets. To ensure sustainable export growth, policymakers should implement three concrete actions: subsidizing first-time export certifications and establishing alternative payment systems to counteract the negative effect of sanctions on the extensive margin; deepening Regional Trade Agreements to reduce non-tariff barriers; and investing heavily in cold-chain logistics to mitigate distance-related trade costs.

**Keywords:** Economic sanctions, Gravity equation, Helpman-Melitz-Rubinstein (HMR), Horticultural exports, Market access, Trade margins.

## 1. Introduction

Exports of horticultural and agri-food products play a crucial role in linking the agricultural sector to domestic and international markets, particularly in developing economies. By generating value added, creating non-farm employment, and enhancing food system resilience, agri-food exports contribute significantly to agricultural development and food security (Abdullahi, 2021). In Iran,

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29 the expansion of horticultural exports has the potential to improve productivity and sustainability  
30 along agricultural value chains, while simultaneously diversifying foreign exchange earnings and  
31 reducing dependence on raw commodity exports. Such diversification is especially important in  
32 mitigating the adverse effects of macroeconomic shocks and international economic sanctions  
33 (Hosseini, 2020).

34 Despite these advantages, Iran's horticultural exports remain below their potential in terms of both  
35 scale and geographical diversification. Existing evidence suggests that export performance in this  
36 sector has been constrained by institutional weaknesses, inadequate trade and logistics  
37 infrastructure, limited market access, and persistent political and economic restrictions  
38 (Aminizadeh et al., 2020; Abdullahi, 2021). As a result, Iran's participation in global agri-food  
39 markets is uneven and highly concentrated in a limited number of destinations and product  
40 categories.

41 Recent developments in the international trade literature emphasize that export growth should not  
42 be assessed solely through changes in total export values. Instead, trade performance can be more  
43 accurately understood by decomposing exports into two distinct components: the intensive margin  
44 and the extensive margin (Hummels & Klenow, 2005; OECD, 2009). The intensive margin refers  
45 to the deepening of existing trade relationships, measured by increased export values of products  
46 already traded with established partners. In contrast, the extensive margin captures the expansion  
47 of trade through entry into new markets or the introduction of new products (Hummels & Klenow,  
48 2005; OECD, 2009). Empirical evidence from developing countries, including Nigeria and India,  
49 indicates that while short-term export growth is often driven by the intensive margin, long-term  
50 diversification and resilience largely depend on the extensive margin (Abdullahi, 2021; Nugrohoa  
51 et al., 2023).

52 In the context of Iran, most gravity-model-based studies have focused on measuring export  
53 potential or efficiency for specific agricultural products such as pistachios, dates, or fisheries,  
54 highlighting the roles of market size, geographical distance, exchange rates, and food safety  
55 standards (Aminizadeh et al., 2020; Mohammadi et al., 2020; Saeid, 2025). However, relatively  
56 little attention has been paid to a systematic analysis of horticultural exports through the lens of  
57 intensive and extensive trade margins, particularly within an environment shaped simultaneously  
58 by economic sanctions, regional trade agreements, and institutional changes. This gap is  
59 noteworthy, as horticultural and processed food products are generally more sensitive than raw

60 agricultural commodities to sanitary and phytosanitary standards, traceability requirements,  
61 packaging quality, and cold-chain logistics (Kareem, 2016; Mohammadi et al., 2020).

62 The literature on economic sanctions and agri-food trade suggests that sanctions can severely  
63 disrupt food trade flows, even when food products are formally exempt from trade restrictions.  
64 Financial constraints, insurance limitations, and transport-related barriers often increase  
65 transaction costs and uncertainty, adversely affecting both producers and consumers (Larch, 2024;  
66 Mohammadi-Nasrabadi et al., 2023). Evidence from sanctions imposed on Russia and the  
67 European Union indicates that such shocks tend to have a stronger negative impact on the extensive  
68 margin by discouraging entry into new markets or product lines while existing trade relationships  
69 may persist, albeit at higher costs and risks (Larch, 2024; Nugrohoa et al., 2023). Conversely,  
70 experiences from countries such as India and Nigeria demonstrate that regional trade agreements  
71 and trade facilitation policies can strengthen both the intensive and extensive margins of agri-food  
72 exports, provided that domestic structural and institutional constraints are addressed  
73 simultaneously (Abdullahi, 2021).

74

### 75 **1.1. Theoretical Background**

76 From a theoretical perspective, the decomposition of trade margins is rooted in the New New  
77 Trade Theory, which relaxes the traditional assumption of representative, homogeneous firms  
78 (Melitz, 2003). According to this paradigm, firm heterogeneity implies that only sufficiently  
79 productive exporters can overcome the fixed costs of entry into foreign markets, thereby shaping  
80 the extensive margin of trade, while variable trade costs influence export values conditional on  
81 market entry, thereby shaping the intensive margin (Helpman et al., 2008; Melitz, 2003). In the  
82 context of horticultural and agri-food products, fixed entry costs such as compliance with sanitary  
83 and phytosanitary standards, certification requirements, packaging standards, and cold-chain  
84 logistics can be substantial, making the explicit modeling of the extensive margin particularly  
85 important (Shepotylo, 2016; Owen & Winchester, 2014).

86 **In recent trade literature, alternative theoretical frameworks such as the Intercountries**  
87 **Trade Force (ITF) model have also been proposed to explain bilateral trade dynamics,**  
88 **emphasizing the role of mutual attraction forces similar to intermolecular interactions**  
89 **(Rasoulinezhad & Jabalameli, 2019). However, when evaluating agri-food exports under**  
90 **severe external sanctions, integrating the standard gravity framework with the dual-margin**

91 **decomposition remains particularly insightful because it explicitly addresses sample**  
92 **selection bias.**

93 Stochastic frontier gravity models to evaluate export efficiency and unrealized trade potential  
94 (Mohammadi et al., 2020). Although the stochastic frontier approach is useful for identifying  
95 inefficiencies and the gap between actual and potential trade, it is less suited to contexts where  
96 zero trade flows reflect market-entry barriers rather than mere underperformance. In sanction-  
97 constrained environments, financial restrictions, insurance barriers, and trade uncertainty may  
98 raise the fixed costs of entering new markets and thus affect the selection process underlying  
99 observed trade flows (Popova & Rasoulinezhad, 2016; **Mohammadi-Nasrabadi et al., 2023**). For  
100 this reason, the two-stage Helpman–Melitz–Rubinstein framework provides a more suitable  
101 empirical strategy for distinguishing between the determinants of export market entry and export  
102 intensity (Helpman et al., 2008).

103 Against this background, the present study aims to identify the key determinants of the intensive  
104 and extensive margins of Iran’s horticultural exports over the period 2001–2023. Specifically, it  
105 examines how destination market size and population, geographical distance, development gaps,  
106 regional trade agreements, and periods of intensified economic sanctions influence each margin of  
107 trade. To this end, exports of selected horticultural products are decomposed into intensive and  
108 extensive margins using a gravity framework combined with the two-stage Helpman–Melitz–  
109 Rubinstein (HMR) approach.

110 **The primary motivation for this study stems from the critical need to diversify developing**  
111 **economies away from resource dependency, coupled with the vulnerability of the agri-food**  
112 **sector to recurrent external shocks like international sanctions (Mohammadi-Nasrabadi et**  
113 **al., 2023). The core problem this research addresses is the methodological and policy blind**  
114 **spot regarding zero-trade flows in sanction-constrained environments. Traditional gravity**  
115 **models and efficiency analyses often conflate prohibitive fixed entry costs (the extensive**  
116 **margin) with variable trade frictions (the intensive margin), leading to misdirected policies.**  
117 **By systematically decomposing export performance, the importance of this study extends**  
118 **beyond the specific case of Iran, offering valuable generalizations for other developing and**  
119 **transition economies facing geopolitical constraints. Because horticultural products are**  
120 **highly sensitive to logistical bottlenecks and financial restrictions, the insights generated here**

121 provide a generalized framework for policymakers globally to design targeted, margin-  
122 specific interventions (Larch et al., 2024).

123 Accordingly, the novelty of this research lies in its dual-margin decomposition of  
124 horticultural exports under the simultaneous pressures of international sanctions and  
125 regional integration. This study makes three distinct contributions to the existing literature:  
126 First, methodologically, it departs from standard gravity and stochastic frontier models by  
127 applying the two-stage HMR framework to correct for sample selection bias (Helpman et al.,  
128 2008). Second, empirically, it provides novel evidence on the asymmetric impacts of economic  
129 sanctions. Third, from a policy perspective, it translates these dynamics into actionable  
130 strategies.

131 The major findings reveal that while market size and regional trade agreements (RTAs)  
132 stimulate both margins, economic sanctions and distance severely hinder market entry, but  
133 show a forced, marginally positive effect on export intensity in existing markets. These  
134 findings yield crucial policy implications, emphasizing that sustainable export growth  
135 requires targeted subsidies for initial market entry, deepened RTAs to lower non-tariff  
136 barriers, and strategic investments in cold-chain logistics to counteract external shocks.

## 137 138 2. Methodology and Data

### 139 2.1 Empirical Framework

140 To identify the determinants of the intensive and extensive margins of Iran's horticultural exports,  
141 this study adopts the two-stage framework proposed by Helpman, Melitz, and Rubinstein (2008),  
142 hereafter the HMR approach. This framework is particularly suitable for analyzing international  
143 trade flows as it allows for a clear distinction between the decision to enter export markets and the  
144 intensity of exports once market entry has occurred, while explicitly correcting for sample  
145 selection bias.

146 Within this framework, export performance is decomposed into two complementary components.  
147 The extensive margin captures the probability that Iran exports horticultural products to a given  
148 destination country in a given year, reflecting market entry or export participation. The intensive  
149 margin, by contrast, measures the value of exports in existing trade relationships, conditional on  
150 positive trade flows. By modeling these two margins separately but consistently, the HMR

151 approach enables a more accurate assessment of how economic, geographical, and policy-related  
152 factors affect different dimensions of export performance.

153 As noted by Popova and Rasoulinezhad (2016), external constraints like sanctions can shift trade  
154 patterns by altering these cost structures, forcing exporters to seek new markets (extensive margin)  
155 or adjust existing flows (intensive margin). By employing the HMR two-stage estimation, this  
156 study explicitly controls for the selection bias and the intensive/extensive dynamics, providing a  
157 more robust estimation of trade determinants in the horticultural sector. While recent studies on  
158 Iran's agricultural exports have utilized stochastic frontier gravity models to measure export  
159 efficiency and potential (e.g., Miranzadeh Mahabadi et al., 2026), this study complements the  
160 literature by adopting the HMR framework to decompose trade flows into intensive and extensive  
161 margins, thereby addressing the zero-trade bias

162

## 163 2.2 Extensive Margin Specification

164 In the first stage, the probability of Iran's horticultural export presence in destination country  $j$  at  
165 time  $t$  is estimated using a random-effects probit model. The dependent variable is a binary  
166 indicator that takes the value of one if positive exports are observed and zero otherwise. The model  
167 is specified as follows:

$$168 P(EM_{jt}=1 | X_{ijt}) = \Phi(\alpha_i + \beta_0 + \sum_k \beta_k X_{ijt,k} + \epsilon_{ijt}) \quad (1)$$

169 Where  $EM_{jt}$  is the binary variable of presence/absence of Iranian Horticultural products exports  
170 to destination country  $j$  in year  $t$  (value 1 indicates presence of exports and 0 indicates absence of  
171 exports),  $X_{ijt}$  is the vector of explanatory variables,  $\alpha_i$  represents the country-specific random  
172 effects, and  $\Phi(\cdot)$  is the standard normal cumulative distribution function.

173

## 174 2.3 Intensive Margin Specification

175 In the second stage, the determinants of export intensity are analyzed conditional on positive trade  
176 flows. Following recent advances in gravity modeling, the intensive margin equation is estimated  
177 using the Poisson pseudo-maximum likelihood (PPML) estimator (Silva & Tenreyro, 2006). The  
178 PPML estimator is robust to heteroskedasticity and naturally accommodates the multiplicative  
179 form of the gravity equation without requiring log-linearization of the dependent variable. The  
180 model is specified in its exponential form as follows:

$$181 IM_{jt} = \exp(\gamma_0 + \sum_k \gamma_k X_{ijt,k} + IMR_{jt}) \times u_{ijt} \quad (2)$$

182 Where  $IM_{jt}$  is the level (actual value) of horticultural products exports from Iran to country  $j$  in  
 183 year  $t$  (measured in thousand USD, not in logarithms);  $X_{ijt}$  is the vector of explanatory variables  
 184 (mostly in logarithmic forms, such as distance and GDP);  $IMR_{jt}$  is the inverse Mills ratio derived  
 185 from the first-stage probit model to control for selection bias;  $\lambda$  is its corresponding parameter;  
 186 and  $\mu_{ijt}$  is the multiplicative error term.

187 It is important to note a methodological limitation regarding the exclusion restriction in the two-  
 188 stage HMR framework. Ideally, the first-stage selection equation (probit) should include at least  
 189 one instrumental variable—such as common official language or colonial ties—that strongly  
 190 affects the probability of market entry but has no direct effect on export volumes. However, due  
 191 to the specific geopolitical and historical characteristics of Iran's horticultural trade network,  
 192 identifying a strictly exogenous valid instrument proved empirically challenging. Consequently,  
 193 as in several foundational studies in the gravity literature, the identification of the inverse Mills  
 194 ratio in the second stage relies primarily on the nonlinearity of the probit model's functional form.  
 195 While this approach is standard in the absence of valid exclusion restrictions, it may introduce a  
 196 degree of multicollinearity or potential bias in the second-stage estimates, which should be  
 197 considered when interpreting the precise magnitudes of the coefficients. The variables used in  
 198 estimating the models and the sources used are reported in Table 1.

199  
 200 **Table 1.** Definition, type, and data source of variables used in the models of the marginal influence  
 201 and export intensity of the Iranian Horticultural products.

Variable Type	Variable	Definition & Unit	Data Source
Dependent	$EM_{jt}^{FI}$	Binary variable:   1 = Existence of exports;   0 = No exports	International Trade Centre (ITC)
Dependent	$IM_{jtFI}$	Level of export value of Horticultural products (1000 USD)	ITC
Independent	$\ln(PCGDP_j)$	Per capita income of destination country (USD)	World Bank
Independent	$\ln(POP_j)$	Population of destination country	World Bank
Independent	$\ln(DIS_{ij})$	Geographical distance between Iran and partner (kilometers)	World Bank
Independent	$\ln(GDPDIF_{ij})$	Absolute difference in log per capita incomes	Author's calculations
Independent	$ASIA_j$	Dummy variable: 1 = Asian partner; 0 = Non-Asian	ITC
Independent	$RTA_{ij}$	Dummy variable: 1 = Joint membership in trade agreements	World Bank
Independent	$SANCT$	Dummy variable: Periods of economic sanctions against Iran	Author's calculations
Independent	$CRISIS_t$	Dummy variable: Years of global financial crisis (2008–2009)	Author's calculations

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## 205 2.4 Data and Variables

206 The empirical analysis is based on a panel dataset covering the period 2001–2023. The sample  
207 includes Iran’s exports of selected horticultural products, specifically classified under HS code 08  
208 (edible fruit and nuts), to 48 destination countries. Export data is obtained from the International  
209 Trade Centre (ITC) database. The selection of explanatory variables is strictly grounded in the  
210 theoretical foundations of the structural gravity model of trade (Tinbergen, 1962; Silva &  
211 Tenreyro, 2006) and the New Trade Theory. Specifically, per capita income and population of  
212 destination countries (sourced from the World Bank) are included as theoretical proxies for market  
213 size, demand capacity, and purchasing power. Geographical distance is incorporated as the  
214 standard proxy for variable trade frictions and transport costs. Furthermore, drawing on the Linder  
215 hypothesis (Linder, 1961), a variable measuring the per capita income gap between Iran and each  
216 partner country is constructed using the absolute difference in their log per capita incomes  
217  $(|\ln(PCGDP_j) - \ln(PCGDP_{Iran})|)$  to capture how structural differences in economic development  
218 and consumer preferences affect trade barriers. Policy-related variables include a dummy variable  
219 indicating common membership in regional trade agreements and a dummy variable identifying  
220 Asian destination markets. The Asian group in our sample broadly covers 44 countries, including  
221 Middle Eastern and Arab states (e.g., Iraq, UAE, Saudi Arabia), Eurasian nations (e.g., Russian  
222 Federation, Armenia), and East/South Asian economies. We also included time-specific dummy  
223 variables representing periods of intensified economic sanctions against Iran (specifically taking  
224 the value of 1 for the peak sanction periods of 2006–2015 and 2018–2023), and the global financial  
225 crisis of 2008–2009. These variables allow the analysis to explicitly account for the effects of trade  
226 policy integration and major external economic shocks on both margins of exports. It is worth  
227 noting that while alternative estimators such as the Heckman two-step or Tobit models have  
228 historically been used to address zero trade flows, this study relies on the PPML estimator. **Recent**  
229 **econometric consensus (Silva & Tenreyro, 2006) demonstrates that PPML is significantly**  
230 **more robust in the presence of heteroskedasticity. Furthermore, to maintain model**  
231 **parsimony and avoid multicollinearity with time-varying macroeconomic shocks (e.g.,**  
232 **sanctions and crises), additional controls such as bilateral real exchange rates and dynamic**  
233 **trade costs (e.g., distance interacted with oil prices) were excluded. The omission of these**  
234 **variables constitutes a limitation of the current study and presents an avenue for future**  
235 **research.**

236 **2.5 Diagnostic Tests**

237 Before estimation, panel unit root tests, including the Levin–Lin–Chu and Fisher-type tests, are  
238 conducted to ensure the stationarity of all variables. Multicollinearity among explanatory variables  
239 is assessed using the variance inflation factor (VIF), with all values remaining well below  
240 conventional thresholds, indicating no serious collinearity concerns. The statistical significance of  
241 the inverse Mills ratio in the second-stage regression is used to confirm the presence of selection  
242 bias and the appropriateness of the HMR framework for the analysis.

243  
244 **3. Empirical Results**

245 Table 4 reports the estimation results for the extensive and intensive margins of Iran’s horticultural  
246 exports over the period 2001–2023 using the two-stage HMR framework. The Wald statistics and  
247 associated p-values confirm the overall statistical significance of both the probit (extensive  
248 margin) and gravity–PPML (intensive margin) models, indicating that the selected explanatory  
249 variables jointly explain a substantial share of the variation in Iran’s export participation and export  
250 intensity.

251  
252 **3.1 Market Size and Income Effects**

253 As shown in Table 4, the per capita income of destination countries exerts a positive and  
254 statistically significant effect on both the extensive and intensive margins of Iran’s horticultural  
255 exports. This result implies that higher-income markets not only increase the likelihood of Iranian  
256 horticultural products entering foreign markets but also facilitate larger export volumes once trade  
257 relationships are established. Similarly, the population size of destination countries displays a  
258 positive and highly significant coefficient in both equations, suggesting that larger markets provide  
259 greater absorption capacity and stronger demand potential for Iran’s horticultural exports. Taken  
260 together, these findings are fully consistent with the predictions of the gravity model and indicate  
261 that market size and purchasing power are key drivers of both export participation and export  
262 deepening.

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268 **Table 2.** Results of the unit root test of the model variables based on the Fisher and Levin-Line  
269 tests.

Variable	LLC	Sig.	Fisher	Sig.
ln(IMjtFI)	–	–	14.916	0.000
ln(PCGDPj)	-10.809	0.000	5.533	0.000
ln(POPj)	-23.942	0.000	92.684	0.000
ln(GDPDIFij)	-7.662	0.000	17.401	0.000

270

271

**Table 3.** Collinearity results (variance inflation factor).

Variable	VIF	1/VIF
ln(PCGDPj)	□□□□	0.436310
ln(GDPDIFij)	□□□□	0.492962
RTAij	□□□□	0.636243
ASIAj	□□□□	0.658362
ln(DISij)	□□□□	0.684256
ln(POPj)	□□□□	0.760986
SANct	□□□□	0.839804
CRISIS <sub>t</sub>	□□□□	0.847238
Mean VIF		□□□□

272

273 **3.2 Trade Costs and Development Gaps**

274 The geographical distance between Iran and its trading partners shows a negative and statistically  
275 significant impact on both margins of trade. According to Table 4, a greater distance reduces the  
276 probability of market entry as well as the value of exports in existing trade relationships. This  
277 finding reflects the role of transport costs, logistics constraints, and cold-chain requirements, which  
278 are particularly relevant for horticultural and food products. In addition, the income gap between  
279 Iran and destination countries negatively and significantly affects the extensive margin, whereas  
280 its impact on the intensive margin is not statistically significant (p=0.375). This result suggests  
281 that large development disparities primarily act as a barrier to market entry. When facing high-  
282 income markets, Iran's initial ability to comply with stringent quality, safety, and packaging  
283 standards may be limited, constraining market penetration. However, once entry barriers are  
284 overcome and trade links are established, the income gap no longer significantly restricts the  
285 volume of ongoing exports.

286

287 **3.3 Regional Characteristics and Trade Agreements**

288 The dummy variable capturing Asian destination markets exhibits a differentiated effect across the  
289 two margins. As reported in Table 4, this variable is not statistically significant in the extensive  
290 margin equation, indicating that Asian markets do not necessarily increase the probability of Iran  
291 entering new export relationships. However, the coefficient is positive and significant in the  
292 intensive margin equation, implying that once export links are established, Asian markets tend to

293 absorb larger volumes of Iran's horticultural exports compared to non-Asian destinations. By  
294 contrast, regional trade agreements (RTAs) display a positive and statistically significant effect on  
295 both margins of exports. Table 4 shows that common membership in RTAs increases both the  
296 likelihood of export participation and the intensity of exports. This result highlights the role of  
297 trade agreements in reducing fixed and variable trade costs, improving institutional compatibility,  
298 and facilitating information flows between trading partners.

299

### 300 **3.4 Economic Sanctions and Global Financial Crisis**

301 The results reported in Table 4 indicate that periods of intensified economic sanctions have a  
302 negative and statistically significant effect on the extensive margin of Iran's horticultural exports.  
303 This finding suggests that the hindrance of new export relationships may be driven by the increased  
304 financial, insurance, and transaction costs typically associated with economic sanctions, acting as  
305 implicit barriers to market entry. In contrast, sanctions are associated with a positive effect on the  
306 intensive margin, though this effect is only marginally significant at the 10% level ( $p=0.055$ ). This  
307 implies a relative concentration and deepening of exports in existing and relatively accessible  
308 markets, highlighting a cautious adjustment strategy where exporters partially compensate for the  
309 loss of new markets by intensifying established relationships. A similar pattern is observed for the  
310 global financial crisis variable. The crisis negatively affects export participation while exerting a  
311 positive influence on export intensity. These results suggest that external shocks tend to restrict  
312 entry into new markets but encourage exporters to rely more heavily on established trade  
313 relationships, leading to what may be described as a forced deepening of existing exports.

314

### 315 **3.5 Sample Selection and Model Validity**

316 Finally, the inverse Mills ratio included in the intensive margin equation is negative and  
317 statistically significant, as shown in Table 4. This result confirms the presence of sample selection  
318 bias and indicates that the decision to enter export markets is not independent of export intensity.  
319 Ignoring this selection process would therefore lead to biased and inconsistent estimates. The  
320 significance of the inverse Mills ratio provides strong empirical support for the use of the two-  
321 stage HMR framework in analyzing Iran's horticultural exports.

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324 **Table 4.** Results of estimating the penetration and intensity model of Iranian Horticultural products  
 325 exports (HMR two-equation model).

<u>Horticultural Exports Penetration Model</u>					<u>Horticultural Exports Intensity Model</u>				
Wald chi <sup>2</sup> = 229.57 Prob> chi <sup>2</sup> = 0.000					Wald chi <sup>2</sup> = 295.73 Prob> chi <sup>2</sup> = 0.000				
Log pseudolikelihood= -848.58165									
Exb	coefficient	Std. err	z	p> z		Coefficient	Std. err.	Z	p> z
ln (PCGDPj)	0.971	0.0956	10.16	0.000	ln (PCGDPj)	1.489	0.165	9.09	0.000
ln (POPj)	0.618	0.0761	8.12	0.000	ln (POPj)	1.033	0.148	6.94	0.000
ln (DISij)	-2.381	0.231	-10.28	0.000	ln (DISij)	-2.612	0.330	-7.91	0.000
ln (GDPDIFij)	-0.227	0.793	-2.87	0.000	ln (GDPDIFij)	-0.082	0.093	-0.89	0.375
ASIAj	-0.069	0.330	-0.21	0.000	ASIAj	0.722	0.404	1.79	0.074
RTAij	0.837	0.303	2.76	0.006	RTAij	0.985	0.272	3.61	0.000
SANCT	-0.476	0.095	-5.02	0.000	SANCT	0.192	0.100	1.92	0.055
CRISIST	-0.285	0.123	-2.32	0.020	CRISIST	0.284	0.099	2.86	0.004
IMR	-	-	-	-	IMR	0.975	0.306	3.17	0.001
_cons	4.824	2.569	1.88	0.060	_cons	-2.520	2.695	0.93	0.350
/insig_u	0.4857	0.2088			Sigma_u	1.6459			
Sigma_u	1.2749	0.1331			Sigma_e	1.1245			
Rho	0.6191	0.04924			rho	0.6817			

326

327 **4. Discussion**

328 The empirical results provide clear evidence that the performance of Iran’s horticultural exports is  
 329 shaped by distinct mechanisms operating through the intensive and extensive margins of trade. In  
 330 line with the gravity model and the predictions of the HMR framework, market size and purchasing  
 331 power in destination countries emerge as fundamental drivers of both export participation and  
 332 export intensity. Higher per capita income and larger population not only facilitate entry into  
 333 foreign markets but also support the deepening of existing trade relationships. This finding is  
 334 consistent with the broader literature on agri-food trade, which emphasizes the central role of  
 335 demand-side factors in shaping export dynamics in developing economies (Hummels & Klenow,  
 336 2005; Abdullahi, 2021).

337 Trade costs, as proxied by geographical distance, exert a systematically negative effect on both  
 338 margins of Iran’s horticultural exports. This result highlights the particular sensitivity of  
 339 horticultural and processed food products to transport costs, logistics efficiency, and cold-chain  
 340 infrastructure. Compared with bulk agricultural commodities, these products face higher risks of  
 341 spoilage and stricter delivery requirements, making distance a more binding constraint. The  
 342 negative effect of development gaps further suggests that large differences in income levels  
 343 between Iran and its trading partners may limit export performance through mismatches in  
 344 consumer preferences, quality standards, and regulatory requirements. Together, these findings  
 345 underscore the importance of reducing effective trade costs through investments in logistics,  
 346 certification, and quality upgrading.

347 The differentiated role of Asian markets across the two margins provides additional insights into  
348 the structure of Iran's horticultural trade. While Asian destinations do not significantly increase  
349 the probability of establishing new export relationships, they play a substantial role in absorbing  
350 larger export volumes once trade links exist. This pattern points to a concentration of exports in a  
351 limited number of established regional markets and suggests that barriers to entry—such as intense  
352 competition, information asymmetries, or market-specific standards—may still constrain export  
353 diversification within Asia.

354 Regional trade agreements emerge as a key policy-relevant factor, positively affecting both the  
355 extensive and intensive margins of exports. This result confirms that trade agreements can  
356 simultaneously lower fixed costs of market entry and reduce variable trade costs, thereby  
357 supporting both market expansion and export deepening. For horticultural and agri-food products,  
358 such agreements are particularly important when they include provisions related to sanitary and  
359 phytosanitary measures, technical standards, and customs facilitation. The findings align with  
360 previous evidence from developing countries, indicating that regional integration can play a  
361 compensatory role in environments characterized by high non-tariff barriers.

362 The results also reveal a distinct asymmetry in the effects of economic sanctions and global  
363 economic shocks. Both sanctions and the global financial crisis are shown to disproportionately  
364 weaken the extensive margin of Iran's horticultural exports, limiting access to new markets and  
365 products. At the same time, their positive association with the intensive margin suggests a  
366 reallocation of export efforts toward existing and relatively accessible markets. This forced  
367 deepening aligns with broader structural shifts in Iran's macroeconomic policies, where external  
368 constraints have historically compelled policy-makers to re-orient trade directions and focus on  
369 non-oil export capacities as a resilience strategy (Taghvaei et al., 2017). This pattern reflects an  
370 adjustment strategy in which exporters respond to heightened uncertainty and rising transaction  
371 costs by concentrating on established trade relationships. While such forced deepening may  
372 partially offset short-term losses, it can reduce long-term resilience by increasing dependence on  
373 a narrow set of markets. Our findings are consistent with earlier evidence showing that sanctions  
374 affect not only the volume of Iran's trade but also its geographical orientation, shifting trade  
375 relations away from Europe and toward Asian partners (Popova & Rasoulinezhad, 2016). This  
376 interpretation supports our result that external restrictions can reshape the pattern of export  
377 relationships, especially by constraining expansion into new destinations (Shirazi et al., 2016). In

378 addition, alternative theoretical frameworks such as the Intercountries Trade Force (ITF)  
379 model suggest that bilateral trade may also reflect attraction-type forces beyond the  
380 conventional gravity structure, although the HMR framework remains particularly suitable  
381 in the presence of zero trade flows and market-entry barriers (Rasoulinezhad & Jabalameli,  
382 2019).

383 Finally, the statistical significance of the inverse Mills ratio confirms the presence of sample  
384 selection bias and validates the use of the two-stage HMR framework. This finding reinforces the  
385 notion that the decision to export and the scale of exports are jointly determined processes and that  
386 ignoring the market-entry decision would lead to misleading inferences about export intensity.

387 Overall, the discussion highlights that policies aimed at promoting Iran's horticultural exports must  
388 address both margins of trade simultaneously. Focusing exclusively on expanding export volumes  
389 without facilitating entry into new markets risks reinforcing existing concentration patterns, while  
390 targeting market diversification without strengthening existing trade relationships may limit short-  
391 term export growth.

392

## 393 5. Conclusions

394 This study examined the determinants of the intensive and extensive margins of Iran's horticultural  
395 exports over the period 2001–2023 using a gravity framework combined with the two-stage  
396 Helpman–Melitz–Rubinstein (HMR) approach. By explicitly distinguishing between export  
397 market entry and export intensity, the analysis provides a more nuanced understanding of Iran's  
398 export performance than approaches focusing solely on total export values.

399 The empirical results show that destination market size and purchasing power significantly  
400 enhance both margins of trade, confirming the relevance of demand-side factors in shaping  
401 horticultural export dynamics. In contrast, geographical distance and development gaps impose  
402 substantial constraints on export participation and export deepening, reflecting the high sensitivity  
403 of horticultural and agri-food products to transport costs, logistics quality, and regulatory  
404 standards. Regional trade agreements are found to play a supportive role by simultaneously  
405 facilitating market entry and strengthening existing trade relationships.

406 A key contribution of this study lies in documenting the asymmetric effects of economic sanctions  
407 and global economic shocks. These external constraints primarily weaken the extensive margin of  
408 exports by limiting access to new markets, while inducing a relative deepening of exports in

409 existing relationships. **This result is consistent with earlier evidence that sanctions may**  
410 **redirect Iran's trade geographically, shifting commercial orientation away from Europe and**  
411 **toward Asian partners, rather than merely suppressing trade volumes (Popova &**  
412 **Rasoulinezhad, 2016). It also supports the argument that sanctions reshape export**  
413 **relationships by discouraging entry into new destinations and increasing dependence on**  
414 **already established markets (Shirazi et al., 2016). Although such adjustment may mitigate**  
415 **short-term export losses, it risks increasing market concentration and reducing long-term**  
416 **export resilience. From a broader theoretical perspective, alternative bilateral trade**  
417 **frameworks such as the Intercountries Trade Force model also suggest that trade relations**  
418 **may reflect attraction-type mechanisms beyond conventional gravity effects, although the**  
419 **HMR framework remains more appropriate for handling zero trade flows and market-entry**  
420 **barriers in the present context (Rasoulinezhad & Jabalameli, 2019).** The statistical  
421 significance of the inverse Mills ratio further confirms that export participation and export intensity  
422 are jointly determined processes, underscoring the necessity of employing a selection-corrected  
423 framework such as HMR.

424

## 425 6. Policy Implications

426 **Based on the empirical findings, three concrete policy actions are recommended to enhance the**  
427 **resilience and performance of Iran's horticultural exports:**

428 Targeted Support to Counteract Sanctions (Extensive Margin): Since economic sanctions  
429 disproportionately hinder market entry, policymakers should provide direct support for first-time  
430 exporters—such as subsidizing sanitary and phytosanitary (SPS) certification costs and  
431 establishing alternative regional financial settlement systems. This action directly mitigates the  
432 prohibitive fixed costs of entering new markets under sanction constraints.

433 Deepening RTAs to Reduce Non-Tariff Barriers (Both Margins): Given the positive impact of  
434 Regional Trade Agreements, especially in Asian markets, trade diplomacy should prioritize  
435 negotiating bilateral agreements that explicitly address non-tariff barriers. Mutual recognition of  
436 phytosanitary standards and customs facilitation within these agreements will lower both fixed and  
437 variable trade costs, thereby supporting both market expansion and export deepening.

438 Investment in Logistics and Cold-Chain Infrastructure (Trade Costs): To mitigate the severe  
439 negative impact of geographical distance on both trade margins, targeted investments in

440 specialized trade infrastructure are essential. Developing modern cold-chain logistics and digital  
441 traceability platforms will reduce effective transport costs and minimize spoilage risks, which are  
442 particularly binding constraints for perishable horticultural products.

443

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حاشیه‌های نفوذ و شدت صادرات محصولات باغبانی ایران: رویکرد مدل جاذبه

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چکیده

مطالعه حاضر با تمرکز بر ویژگی‌های بازار، هزینه‌های تجارت، توافق‌نامه‌های تجارت منطقه‌ای و شوک‌های اقتصادی به تحلیل عوامل مؤثر بر صادرات محصولات باغبانی ایران طی دوره 2001-2023 پرداخته است. در این تحلیل با استفاده از مدل جاذبه و رویکرد دومرحله‌ای هلمین-ملیتز-روبینشتاین (HMR) میان حاشیه نفوذ (احتمال ورود به بازار) و حاشیه شدت (ارزش صادرات) تمایز قائل می‌شود. یافته‌های کلیدی نشان می‌دهد درآمد سرانه و جمعیت بیشتر در کشور های مقصد، تأثیر مثبت بر هر دو حاشیه صادرات داشته، اما افزایش فاصله جغرافیایی بر هر دو حاشیه تأثیر منفی می‌گذارد. همچنین شکاف‌های توسعه‌ای از طریق محدود کردن دسترسی به بازارهای جدید، دارای اثر بازدارنده بر حاشیه نفوذ صادرات دارند. تحریم‌های اقتصادی و بحران مالی جهانی نیز حاشیه نفوذ را تضعیف نموده و دسترسی به بازارهای جدید را محدود می‌سازند اما اثر مثبت بر صادرات در مسیرهای موجود می‌شوند. توافق‌نامه‌های تجارت منطقه‌ای هر دو حاشیه را در بازارهای آسیایی تقویت می‌کنند. سیاست‌گذاران می‌توانند جهت تضمین رشد پایدار صادرات سه راهکار انتخاب نمایند: پرداخت یارانه برای گواهی‌نامه‌های صادراتی جدید و ایجاد سیستم‌های پرداخت جایگزین جهت خنثی کردن اثر منفی تحریم‌ها بر حاشیه نفوذ؛ تعمیق توافق‌نامه‌های تجارت منطقه‌ای به منظور کاهش موانع غیرتعرفه‌ای؛ و سرمایه‌گذاری کلان در لجستیک زنجیره سرد جهت کاهش هزینه‌های تجاری ناشی از بعد مسافت.