Iranian Journal of Economic Studies, 13(1) 2024, 133-158

Shiraz University

Iranian Journal of Economic Studies

Journal homepage: ijes.shirazu.ac.ir

Competing with Low-Cost Imports: Strategic Outsourcing and Firm Dynamics in Traditional Manufacturing – An Agent-Based Approach

Zahra Asadollahi[*a], Hossein Raghfar[a]

a. *Faculty of Social Sciences and Economics, Al-Zahra University, Tehran, Iran.*

Article History

Received date: 15 March 2025
Revised date: 13 May 2025
Accepted date:15 May 2025
Available online: 01 June 2025

JEL Classification

C6
D2
L11
L16
F23

Keyword

agent-based computational model
industrial clusters
traditional manufacturing sectors
globalization, government support

Abstract

This study investigates how traditional, supplier-dominated manufacturing industries (e.g., clothing, furniture) navigate globalization and competition from low-cost offshore suppliers. We develop a hybrid computational model integrating agent-based and system dynamics approaches to simulate interactions among heterogeneous agents—domestic producers, importers, and offshore suppliers—under evolving market conditions, including consumption patterns, tariff policies, and entry rules. The model captures how firms employ adaptive strategies such as outsourcing production while retaining value-added activities compete with cost-efficient rivals. Results reveal that industry resilience depends on proactive enterprises capable of non-technological innovation, differentiating products through aesthetic and strategic competencies rather than technological breakthroughs. Market volatility emerges from incomplete information among new entrants, whose profit-driven entry/exit decisions amplify cyclical fluctuations in producer numbers. While tariffs temporarily shield domestic firms, they fail to address structural disadvantages without complementary investments in adaptive capabilities. Globalization exhibits a dual role: low-cost imports threaten market share, yet strategic outsourcing enables resilient firms to integrate into global value chains, transforming competitive pressures into opportunities. Policymakers are urged to prioritize fostering adaptive ecosystems—emphasizing skill development, branding, and design—over protectionist measures to sustain competitiveness in traditional sectors. The findings underscore the criticality of balancing market openness with strategic support for value-creating competencies in an increasingly globalized economy.

Highlights

- Proactive firms ensure resilience through product differentiation and strategic outsourcing, balancing value creation with cost efficiency.
- Incomplete information among new entrants drives cyclical fluctuations in producer numbers.
- Globalization threatens domestic producers but enables outsourcing for resilient firms to join global value chains.
- Tariffs alone cannot protect industries without complementary investments in design and branding capabilities.

* z.asadollahi@gmail.com
DOI: 10.22099/ijes.2025.52733.2019

1. Introduction

The survival of traditional manufacturing sectors—clothing, furniture, and analogous supplier-dominated industries—represents a critical yet underexplored challenge in an era of intensified globalization. These industries, characterized by small-to-medium enterprises (SMEs) with limited technological infrastructure and reliance on craftsmanship, design, and branding, face existential pressures from low-cost offshore competitors. While such sectors remain vital to regional economies, employment, and cultural heritage, their inherent structural vulnerabilities—weak R&D capabilities, fragmented supply chains, and susceptibility to price competition—raise urgent questions about sustainable adaptation strategies (Naradda Gamage et al., 2020). This study addresses a pivotal gap in industrial economics: How can traditional manufacturers leverage non-technological innovations and strategic outsourcing to transform competitive threats into opportunities within global value chains (GVCs)?

Existing literature predominantly examines these industries through equilibrium-based frameworks or static analyses, oversimplifying the dynamic interactions between heterogeneous firms, policy interventions, and evolving market conditions. Such approaches inadequately capture the feedback loops, path dependencies, and emergent behaviors that define real-world industrial ecosystems. Moreover, while studies acknowledge the role of adaptive strategies like outsourcing, few quantify how firms balance cost-driven externalization with value-retention activities (e.g., design, branding) to sustain competitiveness. To bridge these gaps, we develop a novel hybrid computational model integrating agent-based modeling (ABM) and system dynamics (SD). This methodology uniquely simulates multi-level interactions—micro-level firm decisions, meso-level market fluctuations, and macro-level policy effects—while accounting for incomplete information, behavioral biases, and endogenous shocks.

Our model advances industrial economics in three key dimensions. First, it introduces a granular representation of strategic outsourcing as a dual-edged capability: while offshoring production reduces costs, resilient firms concurrently invest in aesthetic design and branding to differentiate products and capture higher value margins. Second, we demonstrate that market volatility in traditional sectors stems not merely from external shocks but from endogenous cyclicality driven by myopic entry/exit decisions of profit-seeking firms. Third, we challenge conventional policy wisdom by showing that protectionist measures (e.g., tariffs) offer only transient relief unless paired with investments in adaptive competencies. Methodologically, the hybrid ABM-SD framework provides a paradigm shift, enabling scholars to analyze industrial dynamics through a lens of complexity and disequilibrium, surpassing the limitations of reductionist models.

The empirical implications are profound. By simulating scenarios across varying tariff regimes, globalization intensities, and skill-development policies, we reveal that industry resilience hinges on proactive adaptation—firms that internalize design excellence and branding agility outperform peers, even amid import surges. Conversely, sectors reliant on passive protectionism exhibit systemic decline. These findings urge policymakers to prioritize adaptive ecosystems over reactive measures, fostering skill enhancement, collaborative design networks, and GVC integration.

The paper organized as follows: Section 2 critiques extant literature on industrial dynamics and computational economics. Section 3 delineates the hybrid model's architecture, synthesizing ABM's firm-level heterogeneity with SD's macroeconomic feedback structures. Section 4 validates the framework using historical data from the textile industry, while Section 5 employs design-of-experiments methods to test hypotheses on globalization's dual role. Section 6 discusses limitations and future research avenues, concluding with actionable insights for firms and policymakers.

2. A Review of the Related Literature

This review surveys the existing research on firm entry and exit as well as the applications of agent-based modeling (ABM) in these dynamics. We highlight key contributions, identify gaps in traditional and simulation-based models, and explain how our hybrid approach addresses these shortcomings.

2.1 Traditional Approaches and Their Limitations

Economic studies in industrial economics have long relied on the structure behavior performance paradigm, in which market structure (e.g., industry concentration) influences firm conduct (through strategic interactions such as Bertrand or Cournot behaviors), which in turn affects performance (measured by price cost margins or profitability). These analyses typically assume complete information and long-term equilibrium (Kimbrough & Murphy, 2009).

To solve firm decision-making problems, economists generally view the firm as a whole and provide a theory about its interactions. It is usually assumed that the firm has complete information and can make rational decisions to maximize profits. Market power models typically have one of two assumptions: either both firms offer their price and the firm with the lowest price takes over the entire market (called the Bertrand game) or firms produce values called Cournot games on the assumption that other firms do not adjust their values in response to firm decisions (Chang, 2015). However, this approach has been criticized as being too abstract and unrealistic. It also ignores the complexity, heterogeneity, adaptation, and evolution of real-world markets and industries (Chang, 2015). Moreover, it fails to account for external shocks to the demand or production environment that can cause different entry and exit patterns for firms. One such pattern is shake-out, in which the number of producers first increases and then drastically decreases until reaching a stable level (Gabszewicz & Thisse, 1982). Empirical evidence further demonstrates that even similar industries can display markedly different entry/exit patterns under similar growth conditions.

2.2 Advances in Agent Based Modeling

Agent based computational modeling (ABCM) offers a dynamic alternative by simulating economies as a collection of autonomous agents with bounded rationality that interact and learn over time. It is a methodology that uses computer simulations to model complex systems with multiple interacting agents. Agents are autonomous entities with their attributes, behaviors, rules, and goals. They can adapt to their environment and learn from their experience. They can also interact with other agents through communication or competition (Tesfatsion, 2006). Chang believes that one attractive feature of agent-based modeling is its ability to computationally pursue firms' growth and maturity. An industry can be modeled by a demand function or population of potential customers with different utilities for consumption. The latest feature of these models is a set of rules for market interaction so that firms can interact with each other. These interactions also influence decisions about firm entry and exit (Chang, 2011). Knudsen (2017) work advocates for agent-based modeling (ABM) as a transformative methodology in strategic management research. Knudsen argues that traditional analytical frameworks often fail to capture the dynamic, nonlinear, and emergent phenomena inherent in strategic interactions (Knudsen, 2017). Recio et al. study present an agent-based simulation framework that captures the dynamic and evolving nature of modern economies. Designed for both realism and computational efficiency, the platform aims to model the structural evolution of an economic system, including the development of new technologies and products (Recio et al., 2022).

Nelson & Winter (1982) further contribute by modeling firm growth through innovation and imitation. Although their early models—where firms allocate fixed resources to R&D—capture post-entry efficiency gains, they initially omit realistic market forces like demand, price competition, and outsourcing. Subsequent extensions introduced probabilistic entry rules based on profitability thresholds, yet these still fall short of accounting for the complex interplay between local market conditions and global competitive pressures (Nelson & Winter, 1982).

Mazzoli et al. (2019) offer an innovative alternative by embedding firm entry and exit into an oligopolistic, heterogeneous agent framework—using a statistical distribution of expectations based on rational expectations theory. Their model not only simulates dynamic market structures but also reveals phenomena like countercyclical markups, where market structures evolve from concentrated oligopolies to atomistic industries (Mazzoli et al., 2019).

2.3 Empirical Insights on Regional Contexts and Global Competition in Traditional Manufacturing

Empirical studies provide strong motivation for models that integrate local and global factors. Internationally, Feizpour & Moradi (2013) demonstrate that regional characteristics (e.g., GDP growth, urban density, and unemployment) significantly influence firm start up rates in Iranian manufacturing sectors

(Feizpour & Moradi, 2013). Their work resonates with broader agglomeration economy theories (Potter & Watts, 2011) yet often overlooks globalization pressures like competition from low-cost offshore suppliers.

Iranian researchers have similarly contributed to this field. For example, Jalali Naini et al. (2019) develop a DSGE model incorporating endogenous firm entry and exit using Iran's macroeconomic data. Their study reveals that fluctuations in the number of firms profoundly affect business cycle length and magnitude, thereby offering insights into how market shocks are absorbed by both intensive and extensive margins (Jalalinaeni, 2019). Additionally, Azem et al. (2022) investigate the entry and exit dynamics in Iran's food and beverage industries using a GARCH approach to incorporate environmental and structural variables. This study highlights how firm dynamics in Iranian markets are sensitive to local economic conditions and external sanctions (Azem et al., 2022). Moreover, Emami Meybodia et al. (2024) employ a system dynamics-agent based modeling approach to analyze Iranian natural gas production and trade, illustrating the applicability of these methods to other key sectors of the Iranian economy (Emami Meybodi et al., 2024).

In parallel, studies by Chang (2011), Fioretti (2005), and Yang & Ren (2011) offer insights into industrial clusters and self-organizing market structures in dynamic environments (Chang, 2011; Fioretti, 2005; Yang & Ren, 2011). Santos et al. (2016) extend these ideas in a stochastic evolutionary framework to demonstrate how business concentration changes during economic crises (Santos et al., 2016).

Catullo's agent-based model (2012) further contributes by showing that exporters and FDI-active firms tend to score higher productivity through selective entry and efficiency gains, whereas importers benefit from lower unit costs—emphasizing the role of market pressures and integration strategies on price and cost dynamics (Catullo, 2012).

Using a stochastic evolutionary approach, Santos et al. (2016) computationally model firm-level adaptation mechanisms through agent-based simulations grounded in organizational growth theories. Empirical results indicate post-crisis acceleration of oligopolistic tendencies across three manufacturing industries (Santos et al., 2016).

2.4 Contribution: A Hybrid Simulation Approach

Our article extends this rich body of literature through the development of a hybrid simulation model that integrates system dynamics with agent based modeling. Focused on supplier dominated industries, our model simulates the number of firms and their production within a cluster without attempting to explain the introduction of new products. This is justified by the observation that new products typically start with low demand, which then grows gradually through advertising and word-of-mouth (Shimogawa et al., 2012).

Distinctively, our approach incorporates realistic entry criteria: potential entrants compare industry profitability with returns from alternative investments, such as housing, bank interest, or foreign exchange opportunities. Our model also factors in inflation variables that affect pricing decisions and accounts for market saturation that increases entry costs. Notably, we consider the impact of globalization by explicitly modeling the outsourcing of production to foreign suppliers and emphasizing horizontal cooperation among firms. Additionally, our simulation includes scenarios for government support, varying market demand, and overall economic conditions.

By adhering to the "keep it as simple as possible" principle advocated by behavioral economics (Krusell & Smith, 1996) and integrating dynamic models based on differential equations (Cline, 2022), our hybrid simulation framework offers a transparent yet computationally efficient platform. It enables an exploration of both traditional cyclical market behaviors and the subtle interplay between localized market conditions and global competitive pressures.

3. The Study Model

This section presents a hybrid computational model integrating agent-based modeling (ABM) and system dynamics (SD) to simulate the adaptive strategies of firms in traditional manufacturing industries. The model explicitly defines four agent classes, their decision rules (formalized with equations), and their interactions within a dynamic macroeconomic environment. Below is a structured, referee-friendly revision addressing clarity, mathematical rigor, and workflow visualization. Table1, Table2, Table3, Table 4, respectively devoted to Sets and Indices, Parameters, Decision Variables of agents, Other Variables in environment and updating system states.

Table 1. Sets and Indices

Indices	Definition	scope
m	Set of producers/manufacturers	$\{1,2,\dots M\}$
i	Set of importers	$\{1,2,\dots I\}$
t	Set of time periods	$\{0,1,\dots T\}$
f	Set of firms, including producers and importers	$\{0,1,\dots M+I\}$

Source: *The proposed model*

The index "f" is a general term that encompasses both "m" and "i". Therefore, in other tables, when we use the index "f," it implies that it can refer to either a manufacturer or an importer.

Parameters:

Table 2. Parameters

Parameters	Definition	scope
k	Sensitivity parameter of Entry function	calibrated to 0.5 via interviews

μ_{Knew}	Average Capacity of new entrants	average of existing manufacturers′ capacity
σ_{knew}	Standard deviation of Capacity of new entrants	standard deviation of existing manufacturers′capacity
$Q_{f,t}$	Quality of goods produced or imported by firm "m" or "I" in time "t"	Quality of new entrants$\sim N(\mu_Q,\sigma_{cQ})$
α	Optimism factor	$\alpha \sim U[0.1,0.3]$
β	Pessimism factor	$\beta \sim U[0.05,0.2]$
γ	Capital adjustment speed	$\gamma \sim U[0,1]$
M_t	Total number of manufacturers in time t	Started from M_0
PO_t	Total number of potential entrants in time t	$PO_0 = 0.1 * M_0$
T	Total period of time	25
φ	Depreciation rate	0.1
$Ag_{f,t}$	Age of firms	$Ag_{m,0} \sim$ Exponential $[\lambda = 20]$
η	Net birth rate	0.03
inf_t	Growth rate of cost elements	[0.1,0.5]
ICo_t	The cost of importing goods	From Data
$tariff_t$	Tariff rate	From Data
$excange\ rate_t$	Exchange rate	From Data
η	Price elasticity of Demand	From Data

Source: *The proposed model*

Decision Variables are presented in Table 3.

Table 3. Decision Variables

Variables	Definition	scope
$X_{f,t}$	Quantity of goods produced or imported by manufacturer 'm' or importer "i" at time 't'.	$X_{m,t} = K_{m,0}$
$K_{m,t}$	Capacity of manufacturer "i" in time "t"	Capacity of manufacturers in time 0$\sim N(\mu_{K,0},\sigma_{k,0})$
$\pi_{f,t}$	Profit margin of firm 'f' at time 't'.	$\pi_{m,0} \sim U[0,0.2]$

Source: *The proposed model*

Other Variables:

Table 4. Other Variables

Other Variables	Definition
$ROI_{f,t}$	Average Industry Profit/Entry Cost
$ROIalt_t$	Return on alternative investments
$S_{m,t}$	Sale of goods produced by manufacturer 'm' at time 't'
M_t	Total number of manufacturers in time t

I_t	Total number of importers in time t
$Co_{f,t}$	Production or import cost of manufacturer ‘m’ at time ‘t’
$Pr_{f,t}$	Price of firm ‘f’ at time ‘t’
N_t	Population at time ‘t’
Dt	Demand at time ‘t’

Source: *The proposed model*

3.1 Agent Classes and Behavioral Equations

Behavioral patterns extracted from literature and they were further refined through semi-structured interviews with more than 30 producers in Tehran, ensuring alignment with real-world decision-making under Iran’s economic constraints. We try to be dedicated to “keep it as simple as possible” rule for defining behaviors. Parameters (e.g., entry/exit thresholds, optimism/pessimism factors) were calibrated through semi-structured interviews and literature too.

3.1.1 Domestic Producer Firms

Objective: Improve profitability through production, pricing, and capacity adjustments.

Key Behaviors:

1. Production Adjustment:

○ Firm “m” revise output X_t based on prior sales S_{t-1} and their capacity K_t:

$$X_{m,t+1} = \begin{Bmatrix} \max\left\{K_{m,t},\ X_{m,t} \cdot \left(1 + \alpha * \frac{S_{m,t}-S_{m,t-1}}{S_{m,t-1}}\right)\right) if\ S_{m,t} = Q_{m,t} \\ X_{m,t} \cdot (1-\beta) \qquad if\ S_{m,t} < Q_{m,t} \end{Bmatrix} \quad (1)$$

2. Profit Margin adjustment:

○ If firm m has excess inventory at time t they can decide to reduce production like Formula1 or they can reduce profit margin. Firms choose between strategies based on recent profitability; if their rate of return is more than average of industry, they reduce profit margin based of Formula2 and otherwise they reduce their production based on Formula1. It is because Profitable firms prioritize market share retention (margin cuts), assuming they can absorb short-term losses.

Unprofitable firms prioritize cost reduction (workforce cuts and decreasing production capacity) to avoid bankruptcy(Mousavi et al., 2015).

$$\pi_{m,t+1} = max\left(0,\ \pi_{m,t} - \Delta\pi_m\right)\ if\ S_{m,t} < Q_{m,t}\ Else\ \pi_{m,t+1} = \pi_{m,t} * \lambda max \quad (2)$$

$$\Delta\pi_m \sim U\left[\lambda min \cdot \pi_{m,t},\ \lambda max \cdot \pi_{m,t}\right], \lambda min, \lambda max \in [0,1], \lambda min = 0.05, \lambda max = 0.3$$

$$Pr_{m,t} = Co_{m,t} + \pi_{m,t} \quad (3)$$

3. Capacity Expansion: firms can increase capacity if $ROI\_manuf_t > ROI\_alt_t$:

$$Profit_{m,t} = Q_{m,t} * Pr_{m,t} \quad , \tag{4}$$

$$ROI\_manuf_{m,t} = Profit_{m,t} / Capital\ Invested_{m,t} \tag{5}$$

$$K_{m,t+1} = K_{m,t} + \gamma * \left(Q_{m,t+1}^{pred} - K_{m,t}\right) - K_{m,t} * \varphi \tag{6}$$

4. Exit Decision:

○ Firms exit the market if unsold inventory exceeds the inventory threshold for two consecutive periods, or if renewing depreciated capacity proves unprofitable based on Formula5. Additionally, firms are programmed to exit upon reaching a maximum age, which is randomly assigned at the beginning of the simulation based on an exponential distribution. The last term in Formula6 count depreciation of capacity in each tick of simulation.

$$Ag_{m,t+1} = Ag_{m,t} - 1 \tag{7}$$

These behavioral assumptions are consistent with established theories in behavioral economics. For example, loss aversion suggests that cash-rich firms tend to avoid workforce cuts, as such measures are perceived as irreversible losses. Moreover, in line with Simon's (1955) concept of satisficing, firms often rely on simple heuristics—such as maintaining a target cash ratio—instead of engaging in exhaustive optimization(Mousavi et al., 2015).

5. Outsource:

Producers can opt to outsource production if their internal costs exceed the outsourcing costs. Both internal and outsourcing costs are parameters defined by the model's environment and imposed on the agents.

3.1.2 Importers

Objective: Source low-cost foreign goods for domestic markets.

Importers follow analogous equations for import volume, profit margins, and exit decisions, but costs depend on exchange rates and tariffs:

$$Co_{i,t} = ICo_t * (1 + tariff_t) * (1 + excange\ rate_t) \tag{8}$$

3.1.3 Potential entrants

These are secondary agents who decide to enter the market as a manufacture, importer or not enter at all. The average number of potential entrants is influenced by the percentage of unfulfilled demand and the success of existing manufacturers or importers that achieve higher ROIs compared to alternative investments. This feedback from the manufacturing and importing system informs potential entrants about market opportunities. When deciding to enter, a firm chooses between domestic production and importing based on the relative ROIs of these options.

Key Behaviors:

1. Entry Decision:

○ Potential entrants compare the manufacturing and import return on investment (ROI) against alternative investment opportunities and also estimate unfulfilled demand roughly based on the data of previous model ticks. However, this entry is not guaranteed and its probability depends on the difference in entry profits with competing investment profits. The entry probability function is derived from the logistic model, a standard tool in discrete choice econometrics that transforms a linear predictor into a probability between 0 and 1, effectively capturing binary decision-making processes such as market entry (Kong, 2016).

a. Entry probability (logistic function):

$$ROI - Entry_t = \sum_{f=1}^{M_t+I_t} \left(ROI_{f,t-1}\right) / (M_t + I_t), \tag{9}$$

$$P\_entry_p = 1 \div [1 + exp(- k \times (ROI\_Entry_t - ROI\_alt_t))] \tag{10}$$

b. Decide manufacturing or import:

As this article focuses on the manufacturing industry, entry barriers are low. Agents typically compare the average ROI of the two sectors and decide to enter either as manufacturers or importers accordingly. However, cultural or other factors may lead to an exogenous preference for importing or manufacturing. This behavior is commonly observed across various sectors of Iran's industry too, such as clothing and fashion.

$$Enter\ manufacturing\ if: \ AverageROI\ of\ manufacturers > Average\ ROI\ of\ importers + \Delta preference$$

2. Decide about production or import amount: New entrants' production/import quantities are drawn from a normal distribution with mean and variance equal to those of incumbent firms. It is a simple rule and can be improved.

3.2 Environment

The environment defines the physical and institutional context of the system, such as market size, demand function, population growth, consumer preferences, input prices, and inflation rate. To model consumption, it is assumed that the population increases at a fixed rate (0.03), individual consumption is also modeled as a random value with a normal distribution, allowing for variation in consumption rates. Consumption decreases based on the price elasticity of demand and increases with population growth and consumer demand. The system dynamics method is used to model this section.

1. Demand Dynamics:

$$D_t = N_t \cdot \bar{c}t \cdot (Pr_{avg,t}/P_{ravg,t-1})^{-\eta} \quad , \quad Pr_{avg,t} = \sum_{m=1}^{M} Pr_{m,t} \ / \ M_t \tag{11}$$

$$N_t = N_{t-1} * (1 + \eta) \tag{12}$$

Where c is personal consumption.

2. Production and Import Factor Prices (e.g., wages, rent, exchange rate): All cost components are adjusted over time according to their respective growth rates.

$$Co_{m,t} = Co_{m,t-1} * (1 + inf_t) \tag{13}$$

3. Firms share of demand: Market demand D_t is allocated to individual firms through quality-price competition. Each firm's sales $S_{m,t}$ are determined by its relative attractiveness compared to all active firms, where attractiveness is defined as quality per unit price adjusted by the price elasticity of demand "η". This implements a standard multinomial logit choice framework (Federgruen & Yang, 2009) scaled to aggregate demand:

$$S_{f,t} = D_t * \times (Q_{f,t}/Pr_{f,t}^{\eta}) / \sum_{f=1}^{M_t+I_t} Q_{f,t}/Pr_{f,t}^{\eta} \tag{14}$$

- Outcomes: The outcomes measure the performance and characteristics of the system, such as the number of firms, their production levels, their market shares, their profits, etc.

The model runs with different parameter values and initial conditions. We collect data on the outcomes of each simulation run and analyze them using analysis of variance or other statistical means. Figuer1 shows the flowchart of presented model.

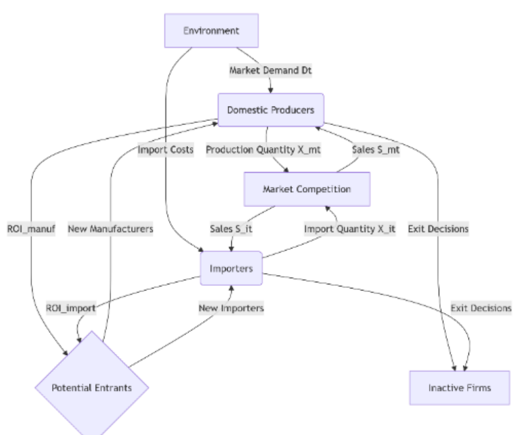

Figure 1. Model Flowchart.
Source*: The proposed model.*

4. Empirical Results

4.1 Model Calibration and Validation

Initially, the model is calibrated using historical data from the Iranian garment industry. Parameters such as population growth rate, average clothing consumption, and inflation rates are derived from Asadollahi et al.'s paper (Asadollahi et al., 2020), Asadollahi's thesis (Asadollahi, 2020) and economic parameters are available in official sites. This thesis rigorously cleansed and validated historical data (1995–2015) for Iran's garment industry, including production volumes, firm demographics, cost structures and most importantly firms' behaviors. We directly incorporated these parameters (e.g., initial firm count, consumption trends) as they align with our model's scope and timeframe. These parameters are incorporated into the model on an annual basis, with the model's year 0 corresponding to 1995 and year 20 to 2015.

In Figure 2, consumption at the current price in the model is compared with historical data. The actual data includes the cost of shoes and clothing, with 20% attributed to the cost of shoes and the remainder to clothing. The Wilcoxon nonparametric test was used to examine the similarity of two data sets, considering the normality and temporal correlation of data in each group. The null hypothesis assumes parity between the medians of the data. The P-value of the test was 0.506, indicating no statistical evidence to reject the null hypothesis. This shows that the average price per period, determined by producers, is sufficiently close to the market price to continue the simulation.

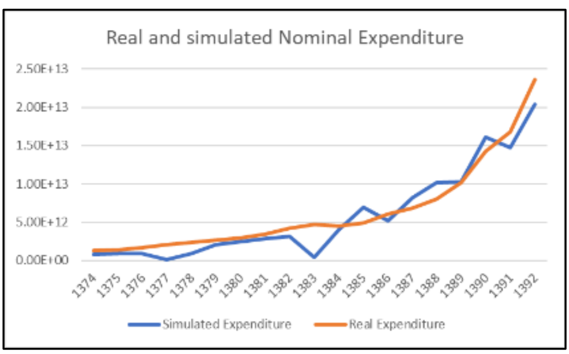

Figure 1. Comparison of Modeled and Historical Consumption Data
Source: *Asadollahi et al. (2020)*

It's important to note that official data dodoes not provide precise figures for the size distribution of products in the industries discussed in this paper. However, according to experts in the Ministry of Industry, Mine and Trade and, and the Garment Trade Union, the number of garment products fluctuated between 5,000 and 7,000 in 2020, the most recent year for which data are available. Furthermore, the data indicate an increase in these numbers during 2008-2009. Given these factors, it is not possible to make an accurate comparison between the data extracted from the model's entry and exit of firms and the historical data.

However, considering the initial assumption that there were 4,000 garment manufacturers in 1996, the fluctuation in the number of manufacturers between 5,000 and 12,400 during these years is reasonable and aligns with expert opinions. Moreover, the downward trend from 2008 onwards, evident immediately after the peak point of 12,400, is consistent with the trend in the number of producers. The entry and exit processes follow an oscillating pattern. The variables related to this process from the model are illustrated in Figure 3. The Figure 3- C represents the estimated real number of producers based on the data.

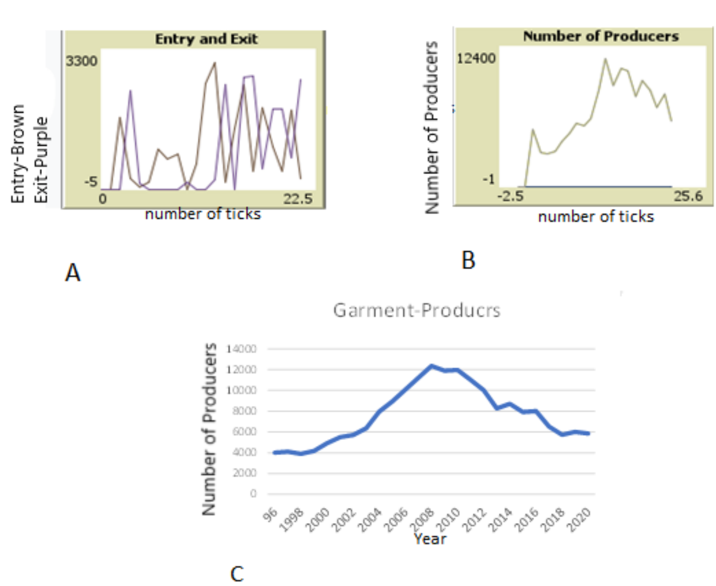

Figure 2: Pattern of Entry and Exit of Firms and Real Number of Producers
Source: *The proposed model*

Another method utilized for validating the model is based on "Industrial Organization" facts. The first phenomenon to note is the shake-out observed in new industries. This has been widely reported and resembles a market crash with a sudden influx of firms at the industry's inception, followed by a rapid withdrawal. However, this phenomenon may not necessarily be observed in every model, depending on the type of industry under consideration. Therefore, it cannot serve as a reference for the validation behavior. The second phenomenon is the continuous entry and exit of firms, even in mature industries. The third observation is that the rates of entry and exit in an industry occur simultaneously. In other words, during periods of high entry rates, the exit rate is also high, indicating a correlation between entry and exit. Finally, the intensity of such structural upheavals varies across different industries. The second and third phenomena were been examined using the proposed model. Eight random model parameters were adjusted at both high and low levels, and experiments were designed using a reduced two-factor design with experimental design tools. The number of entries and exits and the correlation between these two variables were investigated in all experiments over a simulation length of 20 periods. In all experiments, the number of entries and exits with a lag of 1 had a correlation of above 0.35. This is significant, as confirmed by a nonparametric test with a 95% confidence level.

Another approach to model validation is the ‘extreme condition’ or ‘stress test’ method. Figure 4 provides an example of such a test, based on the model's results. This technique tests various parameters at their extreme values to ensure that the model responds logically. For example, if the cost of importing is set near zero, the market would become saturated with imported goods, ultimately leading to imports capturing 100% of the market share.

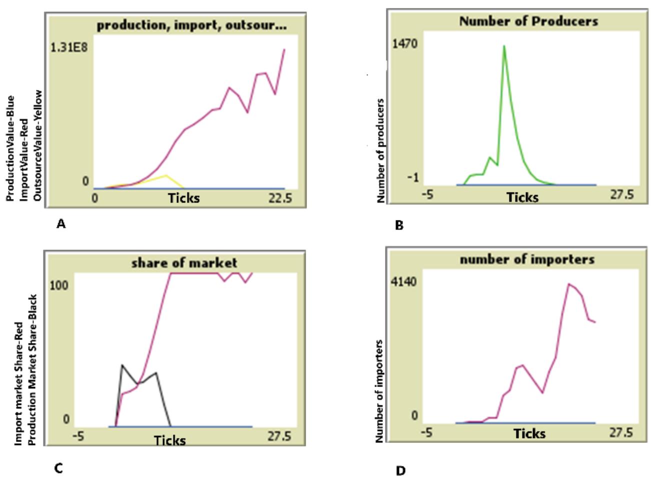

Figure 3. Model Output when Import Price is Near Zero - Extreme Condition
Source: *The proposed model*

4.1 Model Calibration and Validation

In this section, we focus on two main outcomes that are listed and defined in Table 5.

Table 5. outcomes and variables

Variables’ name	Description	Available values
shape-production and shape-producers	The production value and number of producers over the run time have four main shapes. If this variable takes the number 0, it means that the number of producers has generally followed a downward trend after local ascents. In addition, when it takes the number 1, it means that during	[0 ,1, 2, 3] (nominal variable)

	the simulation period, the number of producers generally followed a downward trend generally after ascending; But if it takes the number 2, it means that the number of producers followed an upward trend after ascending and local descents. Number 3 indicates oscillation.	

Source: *The proposed model*

To investigate the effects of the initial number of firms, consumption, and elasticity on production and market dynamics, we perform experiments based on a full factorial design with varying random seeds and other parameters. This approach reduces simulation time and computational complexity, particularly as scaling the number of agents increases processing costs.

Figure 5 illustrates two sample runs, demonstrating that a higher initial number of firms correlates with larger peaks in active producers, higher total production, and elevated entry/exit rates. Diagrams A and D correspond to 6 initial producers, B and E to 12, and C and F to 20. While counterintuitive—given that heightened competition might theoretically deter new entrants—the outcome arises from smaller average firm sizes and a larger pool of potential entrants. The result is statistically significant (p-value ≈ 0), underscoring the critical role of early industry pioneers and government subsidies in catalyzing market activity. These findings align with prior research in the field, reinforcing the model's validity. For example, Martin and Sunley have addressed the dependence on the path in the entry and industrial environment of a region(Martin & Sunley, 2006). Corradini and Vanino have provided evidence of positive complements between industrial path dependence and industrial diversity related to the region for entry of firms into rooted industries existing in a region (Corradini & Vanino, 2021). The number of initial producers in an industry has a significant impact on the trend shape of both producers and production. Industries with a higher number of initial producers tend to experience more oscillation in the number of producers. However, the results indicate a non-linear effect of the initial production. This means that having more initial producers can increase production up to a certain point. In some cases, where there is high initial production relative to the population, the domestic industry may lose its cost advantage over imported goods due to low production volume, rather than the cost of production itself. Additionally, the presence of many existing producers with idle and unused capacity can discourage new entrants into the market.

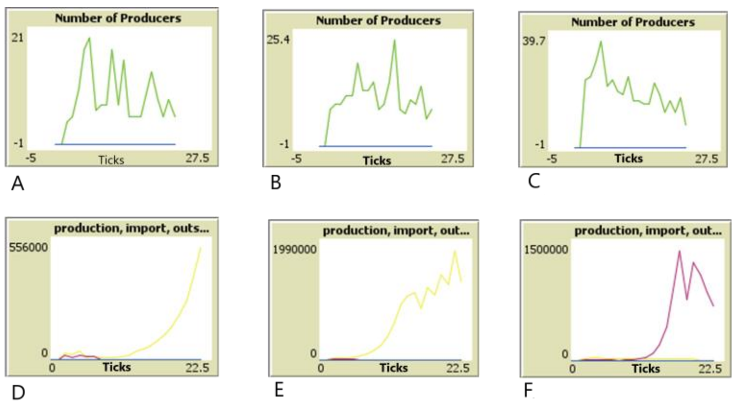

Figure 4. Comparison of the number of producers (Row 1) and production and import (Row 2, production and import are shown by yellow and pink color) with different initial producers: A, D (6 initial producers), B,E (12 initial producers) and C,F (20 initial producers)

***Source**: The proposed model*

As shown in Figure 6, consumption exerts a significant and robust influence on industry dynamics. Steady consumption growth corresponds to a distinct rise-and-fall pattern in the number of active producers (Shape 1) and a gradual increase in production (Shape 2). The prevalence of Shape 1—marked by localized fluctuations—reflects market competition, where only the most profitable producers survive. Further analysis reveals that the expansion phase of producers correlates strongly with unfulfilled demand (positive relationship) and inventory levels (negative relationship). Over time, producers adapt by aligning their output with consumption trends, leading to a decline in their numbers even amid rising consumption. Conversely, consumption declines reduce both producer counts and production, though temporary fluctuations in producer numbers may occur due to localized demand spikes or competitor exits. These findings align with Fatas et al. (2019) study on industrial dynamics, their main findings are that the co-evolution of demand and supply can explain a wide range of industrial structures, from monopoly to perfect competition, depending on three key demand-side factors: consumer insistence, the locality of consumer learning, and consumer loyalty (Fatas-Villafranca et al., 2019).

Statistical testing confirms that individual consumption significantly affects average producer output and total production (p-value = 0.01). However, the shape of producer dynamics (e.g., rise-and-fall patterns) remains unaffected by variations in individual consumption. This conclusion is supported by over 100 model simulations testing three distinct consumption distributions with differing means and standard deviations. Despite these parametric adjustments, the distributional properties of consumption showed no meaningful impact on the characteristic patterns of producer behavior.

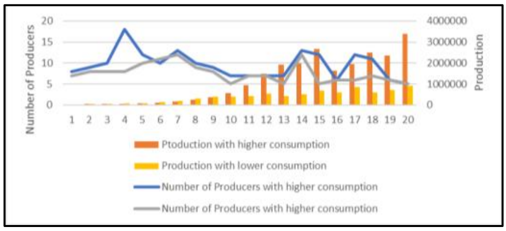

Figure 5. Comparison of the number of producers and production under different levels of individual consumption.
Source: *Asadollahi et al. (2020)*

As shown in Figure 7 and Figure 8, the simulation explores how entrants' capacity decisions shape industry outcomes. Two scenarios were tested:

Scenario 1: New entrants selected production capacities stochastically, using data on the capacities and output levels of profitable incumbent firms.

Scenario 2: New entrants lacked access to complete market data and instead chose capacities stochastically based on partial or imperfect estimates of industry capacity.

The results reveal that entrants' average capacity non-linearly influences total production. Higher average capacity increases output when demand is unmet, while lower capacity reduces it. However, excessive entry—particularly by larger firms—can destabilize the market: smaller firms face cost pressures from rising inventories and competition-driven price constraints, often leading to their exit. Critically, while capacity selection strategies (including variations in distribution parameters) alter production magnitudes, they do not alter the pattern of producer dynamics. Across all simulations with fixed consumption parameters, producer counts consistently followed "Shape 2" (gradual growth in production). This suggests that consumption trends, rather than entrants' capacity choices, determine the fundamental structure of market participation. These finding align with Carbal's (2012) work on shakeout in industry. The researcher demonstrates that sunk capacity costs and strategic hesitancy in technology adoption led firms to minimal initial investments, fostering numerous market entrants. Subsequent industry maturation, marked by a dominant design, prompts surviving entities to optimize capacity, thereby consolidating the market despite rising aggregate output (Cabral, 2012).

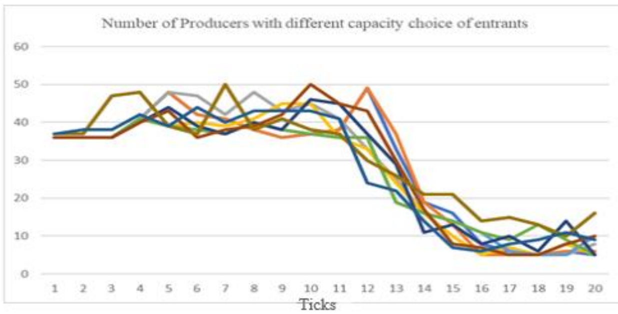

Figure 6. Number of Producers with different capacity choices of entrants.
Source: *The proposed model*

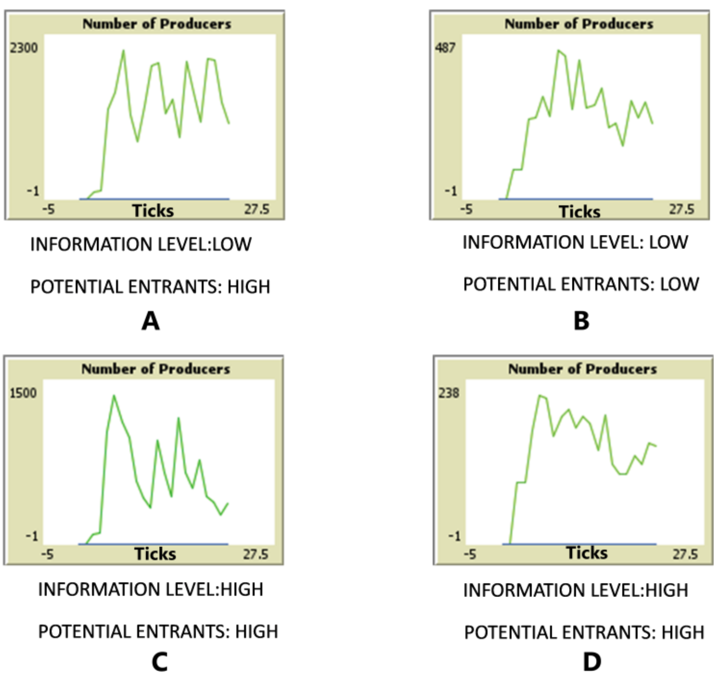

Figure 7. Effect of entering rule and number of potential entrants on the number of producers
Source: *The proposed model*

To further explore the effects of other factors and their contribution to the variability of the results, we conducted a fractional factorial design. We find that material and wage inflation alone does not significantly affect the shape of producers' number, but it does significantly affect the production level and number of producers. When elasticity is low and inflation is high but domestic price is still lower than imported price, production and producers' number curves have a shape of "2" or "3" regardless of population growth; the interaction of firms with each other and the environment are the most effective factors here. When elasticity is high at higher prices, due to a decrease in consumption, the probability of shape 2 increases significantly with a pp-value near zero, and we face lower total production compared to cases with lower inflation after a while with higher inflation. In this situation, producers' size is finally bigger compared with lower inflation. Rent inflation in this model has a slightly different story. An increase, increasing in rent, not only increases the firms' cost but also works as a competitor for production. The inflation rate has significantly increased the logit of shape "2" in both production and producers' number shape. It also has a positive interaction effect with elasticity on the logit of shape "2". Also, firm size increases with an increase in this factor.

According to our model, the factors with the greatest influence on the shape of producers include the rules governing potential entrants, their decision-making process for entering the production system, and the maximum allowable number of potential entrants. Barriers to market entry diminish the pool of viable competitors lead to fewer producers, with their shape tending toward "1." Conversely, factors that increase potential entrants result in more producers, with shapes more likely to resemble "2" or "3." Situations that can reduce the number of potential entrants include: competing activities being more profitable than production, inadequate education and skills, existing entry barriers, and significant influence from current producers and their sales. When current producers strongly impact potential entrants and entrants possess better information, the producers' shape tends toward "1." Another factor affecting the shape, closely tied to potential entrants, is their decision-making process. If potential entrants rely on accurate and comprehensive information from current producers to make decisions, we observe shape "1," with an upward trend aligned with unmet demand. On the other hand, if their decisions are primarily based on price, cost, and personal profit estimations, shape "3" emerges, accompanied by greater fluctuations.

Previous explanations have shown that the number of producers in a market can either exhibit large fluctuations or display a gradual upward trend with minor setbacks, regardless of the growth in consumption and the absence of significant import or outsourcing activities. In this section, we examine the implications of globalization and the emergence of new suppliers who can offer lower prices than the domestic industry. These suppliers have two options: they can either sell their products directly to domestic consumers or supply them to domestic producers who then re-label them as their own.

Figure 9 illustrates three examples of different exchange rates and financial support scenarios for purchasing equipment in situations without outsourcers. Graph A in each row depicts the number of producers, where blue represents outsource producers, green indicates domestic producers, and yellow shows total producers. Graph B presents the total amount of production, imports, and outsourced products, with domestic production shown in yellow, outsourced production in blue, and imports illustrated in red. Graph C displays market share, with red, blue, and black representing import share, outsourced production share, and domestic production share, respectively.

Several factors influence the price of imported goods, including the initial price at the start of the simulation, inflation rates for production inputs, the exchange rate, exchange rate growth, tariffs, and transportation costs. Similar factors apply to outsourced products, except that the government may lower tariffs for outsourced production. When the initial price and inflation of imported goods are lower than domestic products, domestic producers and the government face critical decisions: either outsource production to sell their own branded and designed products in the domestic market, thereby earning added value from design and sales, or allow importers to distribute and sell imported goods, gradually losing added value and market share.

If domestic producers lack the capability to design and sell, and if imported goods remain cheaper than production costs, production levels and the number of producers will decline. This results in either an oscillating trend (shape “1”) or a downward trend (shape “0”) for production and producer numbers. In such cases, providing financial support for existing producers to purchase equipment may exacerbate the situation or yield negligible improvement in production. This is because it may increase other costs or sustain low-quality producers attempting to compensate for inefficiencies by scaling up capacity. Furthermore, in industries where machinery costs constitute a small portion of the final price, such support may have limited impact, though it could contribute to a slight increase in the number of producers.

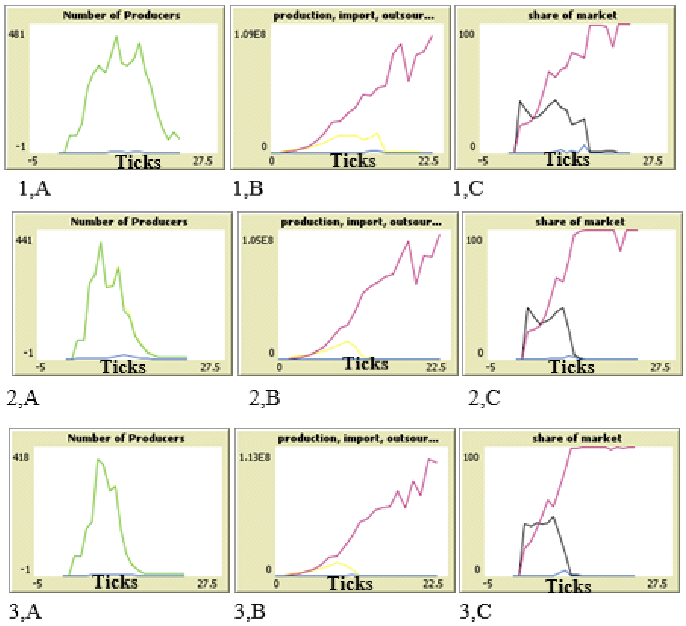

Figure 8. Effects of different scenarios on the number of producers(A), production(B), and market share(C), when production price is less than import price. First row, exchange growth rate: 1.5%, internal inflation rates less than the exchange growth rate. Second row: exchange growth rate: 3% percent, internal inflation rates equal to first row. Third row: exchange growth rate: 3% percent, internal inflation rates equal to first row, financial support to buy machinery.

Source: *The proposed model*

In Figure 10, the impact of import barriers and outsourcing on production is shown. The first row shows the results with a 100% tariff rate for import, and the second row shows the results with a 200% tariff rate. Outsourcing is a way for producers to benefit from the lower costs of new suppliers and maintain profits, even if they must give up production. In this scenario, the product price depends mainly on the offshore production, transportation, cost, transportation cost, exchange rate, design, and marketing costs cost, and marketing cost. Producers who have a strong brand and design value and can ensure product quality can choose outsourcing, which gives them a competitive edge in the market. Otherwise, they have no advantage over imported products. When we run the model with different price settings, we find that outsourcing can result in higher sales in the market than importing and that leaders can earn profit by branding and marketing and even exporting their products. The number of leaders can follow any of the trend shapes defined earlier, depending on the settings. Some producers still produce their own products domestically, but they are fewer than outsourcers, and their trend shape is mostly “0” or “1”. Import barriers can be a policy to support producers, discourage imports, and discourage import and encourage outsourcing or domestic production. However, outsourcing requires high quality design, branding, and sales skills.

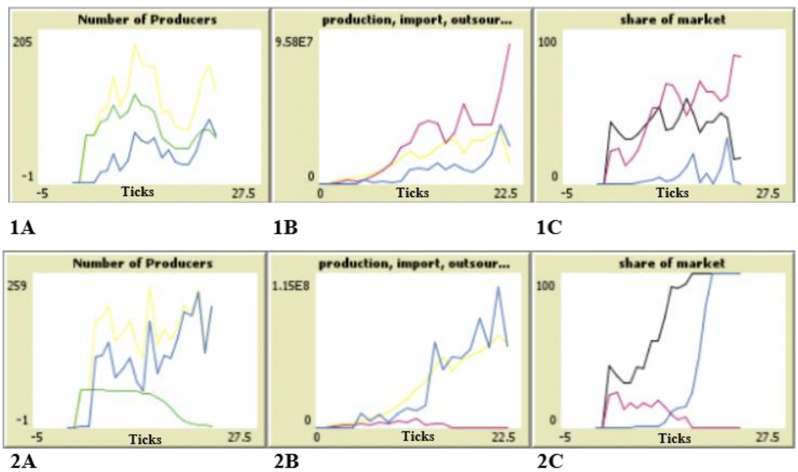

Figure. 10. Impact of import barriers and outsourcing on production. The first row shows the results with a 100% tariff rate for import, and the second row shows the results with a 200% tariff rate.
Source: *Asadollahi et al. (2020)*

5. Concluding Remarks

This study demonstrates that traditional manufacturing industries can navigate globalization by leveraging non-technological innovation and strategic outsourcing, enabling firms to integrate into global value chains (GVCs) while retaining value-added activities like design and branding. However, Iran’s economic realities—chronic inflation, import dependency, and competition from informal markets—require context-specific strategies to sustain competitiveness. The hybrid agent-based and system dynamics (ABM-SD) model reveals that market volatility stems not only from external shocks but also from endogenous cycles of firm entry and exit, driven by incomplete information and profit-seeking behavior. While tariffs provide temporary protection, they fail to address structural inefficiencies such as fragmented supply chains and skill gaps unless paired with investments in adaptive capabilities.

For Iran, policymakers must prioritize fostering adaptive ecosystems over reactive measures. Establishing regional design hubs to train firms in digital branding and sustainable practices, combined with subsidies for certifications (e.g., ISO standards), could enhance export readiness. Strategic outsourcing partnerships, supported by state-backed funding mechanisms, would reduce input costs while incentivizing firms to reinvest in design and marketing. Addressing informality—a critical yet understudied challenge in Iran's industrial landscape—requires tax incentives for SME formalization and stronger intellectual property (IP) laws to protect artisanal designs.

Methodologically, this work advances industrial economics by simulating multi-level interactions (firm decisions, policy shocks, GVC integration) through a hybrid ABM-SD framework, overcoming the limitations of equilibrium-based models. However, the study assumes rational profit-maximizing agents and static macroeconomic conditions, omitting dynamic factors like sanctions-driven supply chain disruptions and informal sector interactions. Calibration relied on aggregate data, warranting validation with firm-level microdata.

Future research should explore the impact of sanctions on cross-border outsourcing feasibility and the role of digital platforms in connecting Iranian SMEs to global markets. Behavioral heterogeneity, such as cultural risk aversion in firm decision-making, could refine agent rules. Explicitly modeling informal firms' interactions (e.g., price undercutting, smuggling) would clarify policy tradeoffs. Finally, empirical validation through case studies of Iranian industrial clusters, such as Tehran's garment district or Isfahan's handicraft networks, would strengthen the model's practical relevance.

In conclusion, sustaining Iran's traditional manufacturing sectors demands balancing market openness with strategic support for value-creating competencies. By transforming globalization from a disruptor into a catalyst for resilience, policymakers can empower SMEs to thrive in an increasingly interconnected yet volatile economy.

Author Contributions

Conceptualization and methodology, all authors; validation, Hossein Raghfar; formal analysis, all authors; original draft preparation, Zahra Asadollahi; writing, review and editing, all authors; supervision, Hossein Raghfar. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no funding from Alzahra University.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data used in the study were derived from publicly available literature and governmental documents.

Acknowledgements
Not applicable

References
Asadollahi, Z. (2020). *Providing the mechanisms success and failure of small and medium producers in Iran's garment and textile industry by applying system dynamics methodology* University of Tehran].

Asadollahi, Z., Shakouri, H., & Raghfar, H. (2020). A system dynamics model to analyze economic challenges of apparel industry: the case study of Iran. *International Journal of Intelligent Engineering Informatics*, *8*(5-6), 497-525. https://doi.org/10.1504/ijiei.2020.115735

Azem, A., Garainejad, g., Daqiqi Asli, a., & Khosravi Nejad, a. a. (2022). Investigating structural and environmental factors on market dynamics in Iran's food and beverage industries. *Quarterly Journal of Quantitative Economics (JQE)*, -. https://doi.org/10.22055/jqe.2022.40257.2480

Cabral, L. M. B. (2012). Technology uncertainty, sunk costs, and industry shakeout. *Industrial and Corporate Change*, *21*, 539-552.

Catullo, E. (2012). *An Agent Based Model Of Firms Selling And Sourcing International Decisions With Flexibility To Demand And Supply Shocks*. https://doi.org/10.7148/2012-0015-0022

Chang, M.-H. (2011). Agent-based Modeling and Computational Experiments in Industrial Organization: Growing Firms and Industries in Silico. *Eastern Economic Journal*, *37*(1), 28-34. https://doi.org/10.1057/eej.2010.30

Chang, M.-H. (2015). *A Computational Model of Industry Dynamics*. Routledge. https://doi.org/10.4324/9781315887241

Cline, D. A. A., Grant T.; Lemp, Christian. (2022). Modeling Empirical Stock Market Behavior Using a Hybrid Agent-Based Dynamical Systems Model. *Northeast Journal of Complex Systems (NEJCS)*, *4*(2), 1-21. https://doi.org/https://doi.org/10.22191/nejcs/vol4/iss2/1

Corradini, C., & Vanino, E. (2021). Path dependency, regional variety and the dynamics of new firm creation in rooted and pioneering industries. *Journal of Economic Geography*. https://doi.org/10.1093/jeg/lbab021

Emami Meybodi, M., Samadi, A. H., Hadian, E., & Mosleh Shirazi, A. N. (2024). Iranian Natural Gas Production and Trade Behavior under Unconventional Gas Developments: A System Dynamics- Agent Based Modeling Approach. *Iranian Economic Review*, *28*(4), 1086-1116. https://doi.org/10.22059/ier.2024.342391.1007444

Fatas-Villafranca, F., M., F.-M. C., & and Vázquez, F. J. (2019). Consumer social learning and industrial dynamics. *Economics of Innovation and New Technology*, *28*(2), 119-141. https://doi.org/10.1080/10438599.2018.1433582

Federgruen, A., & Yang, N. (2009). Competition Under Generalized Attraction Models: Applications to Quality Competition Under Yield Uncertainty. *Columbia: Decision*.

Feizpour, M. A., & Moradi, M. (2013). Determinants of New Firm Formation:

Does Location Matter? . *Iranian Journal of Economic Studies 2*(2), 71-93. https://doi.org/10.22099/ijes.2013.2720

Fioretti, G. (2005). Agent-based models of industrial clusters and districts. In A. Zanfei & P. Pini (Eds.), *The emergence of the knowledge economy* (pp. 181-206). Springer. https://doi.org/10.1016/j.proenv.2013.02.029

Gabszewicz, J. J., & Thisse, J. F. (1982). Entry (and Exit) in a Differentiated Industry. In A. Mas-Colell (Ed.), *Noncooperative Approaches to the Theory of Perfect Competition* (pp. 213-224). Academic Press. https://doi.org/10.1016/B978-0-12-476750-8.50015-4

Jalalinaeni, S. A. R., Tavakolian, H., Zamanzade, H., & DAVOUDI, P. 8(29), 1-39. (2019). Endogenous Firm Entry and Exit in a DSGE Model for Iran Economy *JOURNAL OF APPLIED ECONOMICS STUDIES IN IRAN*, *8*(29), 1-39. SID. https://sid.ir/paper/387028/en.

Kimbrough, S., & Murphy, F. (2009). Learning to Collude Tacitly on Production Levels by Oligopolistic Agents. *Computational Economics*, *33*, 47-78. https://doi.org/10.1007/s10614-008-9150-6

Knudsen, T. (2017). Agent-Based Modelling for Strategy. In F. Wall, S.-H. Chen, & S. Leitner (Eds.), *The Oxford Handbook of Agent-based Computational Management Science* (pp. 0). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197668122.013.6

Kong, E. (2016). Estimating Competitive Effects in Firm Entry with Applications in the Generic Pharmaceutical Industry.

Krusell, P., & Smith, A. A. (1996). Rules of thumb in macroeconomic equilibrium A quantitative analysis. *Journal of Economic Dynamics and Control*, *20*(4), 527-558. https://doi.org/10.1016/0165-1889(95)00863-2

Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. *Journal of Economic Geography*, *6*(4), 395-437. https://doi.org/10.1093/jeg/lbl012

Mazzoli, M., Morini, M., & Terna, P. (2019). Industrial Structure and the Macroeconomy: The Macroeconomic Model and Its Algebraic Framework. In M. Mazzoli, M. Morini, & P. Terna (Eds.), *Rethinking Macroeconomics with Endogenous Market Structure* (pp. 26-74). Cambridge University Press. https://doi.org/10.1017/9781108697019.003

Mousavi, S., Gigerenzer, G., & Kheirandish, R. (2015). Rethinking Behavioral Economics Through Fast-and-Frugal Heuristics. *Behavioral & Experimental Finance eJournal*.

Naradda Gamage, S. K., Ekanayake, E. M., Abeyrathne, G., Prasanna, R., Jayasundara, J. M. S. B., & Rajapakshe, P. S. K. (2020). A Review of Global Challenges and Survival Strategies of Small and Medium Enterprises (SMEs). *Economies*.

Nelson, R., & Winter, S. (1982). *An evolutionary theory of economic change*. THE BELKNAP PRESS OF HARVARD UNIVERSITY PRESS https://www.jstor.org/stable/1912628

Potter, A., & Watts, H. D. (2011). Evolutionary agglomeration theory: increasing returns, diminishing returns, and the industry life cycle. *Journal of Economic Geography*, *11*(3), 417-455. http://www.jstor.org/stable/26162206

Recio, G., Banzhaf, W., & White, R. (2022). From Dynamics to Novelty: An Agent-Based Model of the Economic System. *Artificial Life*, *28*, 58-95.

Santos, J. L., Navarro, T. M., & Pablo-Martí, F. (2016). An Evolutionary Simulation Model of the Effect of Innovation and Firm Dynamics on Market Power.

Shimogawa, S., Shinno, M., & Saito, H. (2012). Structure of S-shaped growth in innovation diffusion. *Phys. Rev. E*, *85*(5), 121-144. https://doi.org/10.1103/PhysRevE.85.056121

Tesfatsion, L. (2006). Chapter 16 Agent-Based Computational Economics: A Constructive Approach to Economic Theory. In L. Tesfatsion & K. L. Judd (Eds.), *Handbook of Computational Economics* (Vol. 2, pp. 831-880). Elsevier. https://doi.org/10.1016/S1574-0021(05)02016-2

Yang, Y., & Ren, L. (2011). *Multi-Agents Model Analysis for the Evolution of Industrial Clusters* Seventh International Conference on Computational Intelligence and Security, Sanya, China. https://ieeexplore.ieee.org/document/6128125