International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 03 Mar. 2025, pp: 283-299 www.ijaem.net ISSN: 2395-5252

The Evolution of Entrepreneurial Activity: A Game-Theoretic Perspective

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Date of Submission: 10-03-2025 Date of Acceptance: 20-03-2025

ABSTRACT: Empirical evidence has indicated that national entrepreneurial activity exhibits a degree of temporal stability. This study employs an evolutionary game-theoretic framework to investigate this phenomenon. By constructing game models that encapsulate the fundamental dynamics of entrepreneurship, researchers have derived the conditions necessary for the emergence of an evolutionary steady-state equilibrium. This equilibrium is characterized by a heterogeneous population, encompassing both agents engaged and disengaged in entrepreneurial pursuits. Notably, analysis has demonstrated that entrepreneurship can persist without reliance on strategic complementarities or group selection mechanisms. Furthermore, researchers have elucidated how the wage-to-self-employment equilibrium provides insights into the enduring debate regarding the distinct characteristics of entrepreneurs relative to other economic agents.

Keywords: Entrepreneurship, evolutionary game theory, market entry games, heterogeneity

I. LITERATURE REVIEW

Contemporary research demonstrates a multifaceted exploration of entrepreneurship, innovation, and intellectual property (IP) across diverse sectors. Studies increasingly emphasize the development of industry-specific entrepreneurial models, exemplified by research in the beauty and healthcare sectors, which highlights value creation through expert insights (AmirzadehVajargah et al., 2024). The digital realm constitutes a significant focus, with investigations into artificial intelligence (AI)-driven electronic customer relationship management (e-CRM) capabilities revealing their potential to enhance digital innovation and competitive advantage in online businesses (Basiri et al., 2023). Furthermore, the role of creativity and emotional advertising strategies in consumer engagement within virtual spaces is underscored (Izadi Jorshari et al., 2023).

Empirical findings suggest a positive correlation between investments in advertising and research and development (R&D) and entrepreneurial orientation (KhodadadiParashkouh et al., 2023). Social media activities are recognized as crucial drivers of customer-brand relationship building and e-purchase intentions (Daneshfar et al., 2023). Context-specific entrepreneurial challenges and opportunities are addressed in studies examining green entrepreneurship in the waste industry and barriers encountered by rural women entrepreneurs (Parhizkarkhadiv et al., 2023; Safari Paskeh et al., 2023). The dynamics of digital entrepreneurship in the cosmetics and hygiene industry are attributed to technological, infrastructural, and strategic factors (Farzpourmachiani A. et al., 2023). Moreover, the concept of entrepreneurship extends beyond traditional business models, encompassing architectural entrepreneurship and its impact on urban landscapes (RahmanzadMasouleh et al., 2025).

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Intellectual property rights (IPR) are recognized as pivotal for economic development, fostering innovation and attracting investment (Farzpourmachiani M. et al., 2024). The intricacies of IPR within the context of AI-driven innovation necessitate a critical re-evaluation of existing patent systems (BakhshandehAbkenar et al., 2024). Studies examining specific innovations, such as liquid level and conductivity measurement methods, tabletop games, and multi-functional adobe bricks, illustrate the commercial potential of IP-protected technologies (Basiri et al., 2023; Farzpourmachiani A. et al., 2022a, 2022b). Innovation and entrepreneurship are vital in the medical device industry, addressing patient needs and improving healthcare outcomes (Seyednouri et al., 2025). Assistive technologies, such as IP-protected insole designs, enhance the quality of life for individuals with medical conditions (Farzpourmachiani M. et al., 2022c).

Strategic thinking is identified as essential for organizational adaptation and success in volatile business environments (Beykzade et al., 2023a, 2023b; Khedri et al., 2023a, 2023b, 2023c, 2023d). Technological innovation, exemplified by a home yogurt maker with a concentration system, demonstrates its connection to entrepreneurial opportunities (Farzpourmachiani M. &Farzpourmachiani A., 2021). The "Attrition Entrepreneurship Theory" posits that not all entrepreneurial activities contribute to societal wealth (Farzpourmachiani M. &Farzpourmachiani A., 2024).

Social entrepreneurship and the identification of entrepreneurial opportunities are influenced by individual factors and backgrounds (Seyedein et al., 2023a). Organizational atmosphere significantly impacts entrepreneurship within organizations (Seyedein et al., 2023b). Problem-solving styles correlate with job satisfaction among employees (Seyedein et al., 2023c). The quality of luxury goods, particularly in the automotive industry, is analyzed through intrinsic and extrinsic attributes (Seyedein et al., 2023d). A holistic IP portfolio, grounded in the Resource-Based View and Dynamic Capabilities Theory, drives entrepreneurial success in invention-based technological ventures (Basiri et al., 2025).

II. INTRODUCTION

Global entrepreneurial activity exhibits substantial and persistent cross-national variation, suggesting inherent structural characteristics within societies. While historical data reveal fluctuations in collective entrepreneurial rates, endeavors involving uncertain projects with potential economic and social benefits have existed since antiquity. Although the potential benefits of entrepreneurship for individual and societal prosperity appear intuitively favorable, empirical observations present a more complex picture. The Global Entrepreneurship Monitor reports that approximately 10% of the working population engages in nascent entrepreneurial activity annually; however, most individuals remain within traditional employment structures, and many ventures fail. Furthermore, not all entrepreneurial pursuits contribute positively to societal welfare; rent-seeking and other unproductive activities may be classified as entrepreneurial, contributing to a relatively stable proportion of self-employed individuals.

Previous research has largely employed general equilibrium models of occupational choice, assuming a continuum of factors characterized by varying entrepreneurial abilities. These models identify a "marginal entrepreneur" indifferent between self-employment and traditional work. However, these equilibrium approaches rely heavily on assumptions regarding preferences, attitudes, beliefs, motivations, abilities, efforts, and information. Empirical research seeking to differentiate entrepreneurs from non-entrepreneurs based on personality traits, attitudes, or behaviors has yielded inconclusive results. While no significant differences in personality traits have been demonstrably observed, entrepreneurs tend to exhibit higher levels of optimism and overconfidence.

Recognizing human diversity across various dimensions, including job preferences, risk tolerance, skills, and information access, necessitates a re-evaluation of our understanding of entrepreneurship. This paper proposes an evolutionary game theory perspective to address this challenge. Evolutionary game theory models behavior through frequency-dependent fitness, assuming that strategies follow recurrence patterns. We focus on evolutionary stable strategies (ESS), which, if adopted by most of the population, cannot be invaded by alternative strategies. We analyze market entry and job-choice games, considering homogeneous, generally heterogeneous, and heterogeneous entrepreneurial populations.

Leveraging evolutionary game theory, we determine conditions for ESS, exploring the effects of entrepreneurship on this dynamic. Our framework provides a criterion for evaluating whether entrepreneurs differ from other economic

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agents based on individual factors. Our findings suggest that individuals with strategies constrained by payoff factors earn different equilibrium payoffs. While empirical evidence remains inconclusive, it is insufficient to reject the homogeneity hypothesis. This paper contributes by enriching theoretical perspectives and proposing an alternative test for a central research question.

III. ECOLOGICAL PERSPECTIVE ON ENTREPRENEURSHIP

The ecological approach has significantly shifted the focus of entrepreneurial research from individual traits to the environmental factors influencing organizational formation. This "quantitative" perspective emphasizes the influence of target groups, organizations, populations, and societies on entrepreneurial activity at a contemporary level of analysis.

Proponents of this view argue that understanding entrepreneurship involves not only the processes by which firms are founded but also the interplay between entrepreneurial strategies (such as entry, innovation, and imitation) at the population level. The ecological perspective rests on concepts such as diversity, adoption, selection, and maintenance. Entrepreneurial ventures, often characterized by novel organizational structures, products, technologies, or markets, arise from sources of diversity. These ventures may also undergo adaptive processes to ensure survival in their environment.

Crucially, environmental conditions and the strategies employed by others within the population influence which behaviors are selected and ultimately maintained. Hannan& Freeman (1984) posited that selection mechanisms play a particularly dominant role in environments characterized by uncertainty, instability, and a lack of clear understanding between actions and outcomes. In such contexts, the correlation between individual intentions and organizational outcomes weakens considerably. Given the absence of established knowledge bases or well-defined pathways for implementation, entrepreneurship naturally exhibits characteristics aligned with evolutionary dynamics.

The ecological approach to entrepreneurship offers several key contributions:

- **Shifting Focus:** By emphasizing outcomes over intentions and adopting a dynamic perspective, it moves beyond individual agency.
- **Cumulative Perspective:** By considering both inter- and intra-population processes, it highlights the cumulative nature of entrepreneurial activity and its interaction with the environment.
- **Path Dependency:** Emphasizing nonlinearities and increasing returns, it underscores the path-dependent nature of organizational foundations.
- **Behavioral Focus:** Conceptualizing entrepreneurs as innovators or exploiters directs attention to two fundamental behaviors employed by entities within their environment.

This ecological perspective highlights the general relevance of evolutionary game theory in understanding entrepreneurial phenomena.

IV. EVOLUTIONARY GAME THEORY AND THE SOCIAL SCIENCES

Evolutionary game theory offers a powerful framework for understanding entrepreneurial phenomena by modeling behavior at the population level. This approach posits that the relative fitness of different strategies depends on their prevalence within a given population.

Key Concepts:

- **Evolutionary Fixed Strategies:** These are strategies that, once adopted by a majority of the population, resist displacement by alternative behaviors due to their inherent advantage in the prevailing context.
- **Myopic Decision-Making:** Evolutionary game theory assumes individuals make choices based on observed patterns rather than complex predictions of future outcomes. This aligns with the often-limited information and uncertain environments faced by entrepreneurs.

Applications to Entrepreneurship:

Evolutionary game theory's focus on myopic decision-making, inertial cumulative behavior, and large populations resonates strongly with entrepreneurial dynamics:

- **Information Asymmetry:** Entrepreneurs frequently lack comprehensive information about competitors, customers, and market trends. They often rely on observing successful strategies adopted by others.
- **Uncertainty and Adjustment Costs:** Entrepreneurial environments are characterized by volatility and uncertainty. Significant adjustments in strategy can be costly and time-

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consuming. Consequently, gradual shifts in behavior occur as entrepreneurs observe the effectiveness of various approaches.

Iterative Dynamics:

Evolutionary game theory often employs iterative dynamics, where population strategies evolve based on their relative performance in previous periods. This mirrors several aspects of entrepreneurial activity:

- **Imitation and Social Learning:** Successful entrepreneurial ventures are often imitated by others, leading to a diffusion of effective strategies throughout the market.
- **Adaptive Strategy Formation:** Entrepreneurs continually assess the effectiveness of their chosen strategies and adjust them based on market feedback and competitive pressures.

Relevance to Cultural Evolution:

The application of evolutionary game theory extends beyond purely biological systems. It provides valuable insights into cultural evolution, highlighting how behaviors spread through imitation, social learning, and other transmission mechanisms within populations. This lens allows us to understand how entrepreneurial practices and innovations evolve and diffuse within societies.

In conclusion, evolutionary game theory offers a compelling framework for analyzing the complex interplay of individual decisions, market dynamics, and population-level effects in the realm of entrepreneurship. Its emphasis on myopic decision-making, inertial behavior, and iterative dynamics aligns with the realities faced by entrepreneurs operating in dynamic and often uncertain environments.

	E	-E
E	$\pi - C$, $\pi - C$	π , w
-E	w , π	w , w

Figure 1- Payoff table of the symmetric market entry game with pairwise interaction

V. ENTREPRENEURSHIP FROM A GAME-THEORETIC EVOLUTIONARY PERSPECTIVE

The complexity inherent in entrepreneurial phenomena transcends the scope of simple game models. While valuable insights can be gleaned from such simplifications, a nuanced understanding necessitates recognizing the multifaceted nature of entrepreneurship.

Existing literature broadly categorizes entrepreneurial representations into two primary paradigms:

1. Environmental Uncertainty:

This view conceptualizes entrepreneurs as solitary decision-makers navigating environments characterized by inherent randomness and unpredictability. The entrepreneur's choices—whether to pursue a novel venture or accept conventional employment—are influenced by uncertain payoffs stemming from an unknown distribution. These outcomes, determined by external forces ("nature"), are not subject to strategic manipulation within perfectly competitive markets.

2. Strategic Uncertainty:

This paradigm portrays entrepreneurs as embedded within intricate networks of interconnected actors. Their decisions are not isolated but profoundly influenced by the actions of stakeholders such as shareholders, competitors, consumers, and government entities. Consequently, entrepreneurial choices become entangled in a dynamic web of interdependent strategic interactions where payoffs are contingent upon the decisions of others.

Examples of this interdependency include:

- **Market Entry Strategies:** Decisions regarding market entry within imperfect competition landscapes, where competitor actions directly impact an entrepreneur's success.
- **Technological Choices:** Navigating alternative technologies amidst market dynamics and competitive pressures, where rivals' actions influence the viability of specific technological paths.
- **Financing Decisions:** Seeking funding under conditions of asymmetric information, where entrepreneurs must anticipate the behavior of investors and navigate their risk appetites.

Modeling Entrepreneurial Choices:

To capture these multifaceted realities, we propose two distinct game models:

1. **Market Entry Game:** This model simulates the strategic interaction inherent in market

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entry scenarios. Entrepreneurs' success hinges not solely on their individual decisions but also on the collective choices of other potential entrants, given a finite market capacity. This captures the competitive dynamics and interdependence characterizing market entry.

2. **Job Choice Under Uncertainty Game:** This model reflects the environmental uncertainty paradigm where entrepreneurial outcomes are influenced by unmodeled factors such as technological advancements, consumer demand fluctuations, and macroeconomic trends ("nature"). While this game does not explicitly involve strategic competition between entrepreneurs, it highlights how external forces shape entrepreneurial choices.

Equilibrium Analysis:

Subsequent sections will delve into the equilibrium properties of these games, analyzing their stability and implications for understanding entrepreneurial decision-making within different contexts.

By employing these models, we aim to illuminate the intricate interplay between individual agency, strategic interactions, and environmental contingencies that define the complex realm of entrepreneurship.

5-1-A Model of Simultaneous Market Entry Decisions

Consider a large population of individuals who, in each period, independently decide whether to enter a given market E or remain in a safe occupation denoted by ~E . This decision is made simultaneously, without communication between individuals. Initially, we assume that individuals play the game in pairs following random selection.

The payoff matrix for this scenario is presented in Figure 1. If only one player enters market E , the entrant receives a payoff of π while the stayer receives a payoff of w . When both players enter, competition drives the individual payoffs down to a value C . Choosing no entry (~E) yields a safe payoff of W . This framework assumes that entering the market implies a higher payoff than a safe occupation when no one else enters (π >W) but a lower payoff when competing with others (C <W).

The risk involved in this decision is strategic, as it depends on the choices made by other potential entrants. For instance, if an individual anticipates another player entering, their best response is to stay and choose ~E , maximizing their payoff at w . In this game, individuals' actions represent strategic alternatives because simultaneous entry into the market reduces the payoffs of both players. Asynchronous solutions, where individuals enter the market consecutively encountering those who remain in safe occupations, would yield higher average payoffs for entrants.

While we can assume that C and π are random variables with either a known or unknown distribution, this uncertainty does not fundamentally alter our analysis of how players coordinate their actions and allocate between the two activities. In evolutionary games, players require an understanding of their overall payoff structure. While individuals may act based on thoughtful considerations, their behavior can also be influenced by established ground rules, social norms, or dynamic analogies to choice mechanisms.

Our analysis begins with the question: Does any strategy exist in this game such that, if most members of the population adopt it, no other strategy can successfully replace it? To answer this, we define the concept of an evolutionary stable strategy (ESS) and determine which strategies are superior. A strategy is considered ESS if it meets two criteria:

1. **Self-Sustainability:** It yields a higher or equal pay off against itself compared to any alternative aggressive strategy.
2. **Dominance Against Aggressors:** When facing another aggressor, it yields a greater payoff than any other aggressor.

The first condition guarantees the existence of an equilibrium where, once the population reaches an evolutionary steady state, no individual can benefit from unilaterally changing their behavior. The second condition ensures the stability of this state, guaranteeing that the population will revert to it if slightly perturbed.

In our specific game, each strategy performs best against the opposing strategy but not against itself. Consequently, their strategy yields a higher fitness (w) and subsequently spreads throughout the population (individuals start imitating this behavior). Conversely, if almost everyone is an entrepreneur, mutations adopting this behavior will also spread because they acquire π, which exceeds w.

Therefore, how does the population evolve?

In the present model, the population evolves towards a stable coexistence state where entry occurs with frequency p = (π-w /C) and non-

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entry occurs with frequency 1-p . As expected, the probability of entry increases with the expected profit in the absence of competition (π) and decreases with the opportunity cost of entry (w) and the expected loss due to competition (C). In this steady state, the probability of being paired with an entrant is p, so the expected payoff to entry, p (π-c) + (1-p) π, equals the payoff to the safe choice w. To verify the stability of this state, consider a scenario where a small number of individuals enter with probability q >p. We denote these types of entrants as q - and p -, respectively. Condition 1) is satisfied by equality since any solution gains w against p -. Therefore, we need to confirm condition 2). Suppose that in the population, entry occurs with frequency q. The expected payoff for q - entrants is equal to:

F(q,q)=q[q(π-C)+(1-q)π]+(1-q)[qw+(1-q)w]

If the expected return to entrants p*- is equal to:

F(p*,q)=p*[q(π-C)+(1-q)π]+(1-p*)[qw+(1-q)w]

By comparing these two equations, we can readily verify that the second condition holds if C > 0. This result highlights a crucial insight from this simple model: in games or market interactions where the costs of competition are significantly higher relative to the rewards of success, we anticipate observing pluralistic behavior. This means that multiple strategies, such as both entry and non-entry, will coexist within the population at a stable level.

Our previous analysis focused on pairwise interactions between individuals. We can extend this model to consider situations where individuals interact with the entire population and the market capacity allows for more than two entrants. In this case, individuals are said to be "playing in the field." Despite this change in scale, the fundamental explanation for why multiple behaviors at the population level remain evolutionarily stable remains valid.

When defining evolutionary steady states in this larger context, we simply need to acknowledge that payoffs are now directly influenced by the cumulative frequency of each behavior within the population. This means that the success of any particular strategy depends not only on its inherent characteristics but also on the overall composition of behaviors present in the market.

5-2- Pluralistic Behavior in Market Entry Games

The evolutionary steady state in which both entry (E) and non-entry (~E) coexist can be achieved through two distinct mechanisms.Firstly, each individual chooses between E and ~E independently with probabilities p and 1-p, respectively. This scenario implies a random selection of strategies within the population.

Alternatively, the population could be divided into two groups: one dedicated to E with proportion p, and another committed to ~E with proportion 1-p. In this case, individuals are "locked" into their chosen strategy. For instance, if 10% of the population chooses E , each individual has a 10% probability of encountering an entrant or 10% of the population is exclusively dedicated to market entry while the remaining 90% remain in safe occupations.

While the first case appears to involve random strategy selection, Sigmund (1993) argues that nature often presents scenarios where complex deterministic causality can be mistakenly perceived as randomness. Environmental cues and chance events may influence individual decisions, mimicking a randomized process. In this context, individuals might not actively choose their strategies randomly but rather react to environmental factors in a way that appears random.

The second case, with two distinct groups, assumes individuals are committed to their chosen strategy based on the perceived probability of encountering an entrant (10% in our example). Notably, both scenarios lead to the same steady state despite differing individual behaviors. This implies that individuals in a polymorphic steady state have no inherent preference for either E or ~E as both yield the same expected payoff.

The model does not explicitly address the incentives or resource constraints driving individual choices between the two options. Importantly, this highlights a key distinction: homogeneous populations (first case) versus heterogeneous populations with pre-determined strategy affiliations (second case). Although both scenarios lead to the same outcome, the underlying mechanisms differ significantly. Empirical data are crucial for distinguishing these cases and understanding the true drivers of individual behavior within a pluralistic market environment.

Despite this limitation, the model effectively demonstrates that even homogeneous populations can exhibit realistic and diverse behavior.

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5-3- Asymmetric Roles in Evolutionary Game Theory

Section 5-1 examined games where individuals exhibited no inherent differences impacting their strategies. However, this assumption does not always hold. Two primary sources of asymmetry exist in game theory:

Firstly, even identical individuals may assume distinct roles within a game. For instance, one participant could be an entrepreneur while another is a landlord, or one individual might possess a patent while another lacks it.

Secondly, the same strategy combination can yield disparate payoffs depending on who implements it. Entrepreneurs, for example, might differ in their knowledge, resources, and consequently, their probabilities of success. This section focuses on the first source of asymmetry, while the subsequent section addresses the second.

Consider the game depicted in Figure 1, characterized by symmetric payoffs. Remarkably, players can achieve average payoffs exceeding 'w' by coordinating actions through a conditional strategy: "Enter if row player, stay if column player." Under this strategy, row players earn π and column players earn W. Since both payoffs exceed w (regardless of an individual's role), this behavior demonstrably satisfies the conditions of evolutionary stability. In an evolutionary context, individuals employing this strategy might outcompete other behaviors by avoiding competition costs 'C', potentially displacing even the plausible or evolutionarily stable polymorphism analyzed in Section 5.1.

The initial conditions determine whether a row or column player chooses entrepreneurship. Crucially, within this evolutionary stable state, individuals occupy distinct roles, with no need for additional roles to maintain equilibrium if they belong to separate populations. Interactions between these populations pit one against the other, leading to specialization and different payoffs for each population. Conversely, if interactions occur within a single population, the aforementioned conditional solution is played by individuals achieving an expected payoff of (π+w)/2, assuming equal representation of both roles.

However, this type of equilibrium loses empirical relevance when role identification is subject to noise or uncertainty, and interactions involve numerous individuals, a common occurrence in entrepreneurial contexts. Roles are more likely to emerge in pairwise encounters rather than when payoffs depend on collective population behavior (i.e., playing the field). Furthermore, as one reviewer astutely points out, roles can be subject to population evolution and choice of membership. If one population enjoys higher income, individuals might migrate or strive to improve their fitness within that population.

If the signal identifying roles is linked to human capital or resources (general heterogeneity), individuals can potentially switch populations. However, if the signal relates to inherent traits (entrepreneurial heterogeneity), such adjustments are unlikely in the short term, requiring the signal to be considered fixed. In cases of fixed roles, we cannot anticipate a payoff equilibrium. Conversely, if roles allow for selection or evolution, group membership dynamics should progress towards the expected payoff equilibrium.

5-4-Entrepreneurship as an Asymmetric Game

While market entry rules capture the competitive essence of entrepreneurship by assuming a pre-existing market and uncertainty as the primary driver, they often overlook crucial economic factors influencing entrepreneurial decisions.

Traditional "game against nature" frameworks posit that individuals solely choose between entrepreneurship (E) and employment (~E), with success probabilities (p) and outcomes determined by chance. However, real-world entrepreneurial choices are shaped by a complex interplay of economic forces beyond mere market competition.

To address this limitation, we introduce economic factors into the framework. Let's assume:

- **Individual Skills:** Individuals are categorized into two types (1 & 2) based on their inherent skills, reflected in their respective wage rates (w₁,w₂).
- **Wage Differentiation:** The wage earned when another individual chooses entrepreneurship (W) is higher than the wage earned when both individuals opt for employment (w), acknowledging potential spillover effects or increased demand for skilled labor.

This expanded model, depicted in Figure 2, acknowledges that individuals weigh not only the inherent risk of entrepreneurship but also the economic context shaping their earning potential.
By incorporating these economic factors, we move beyond a simplistic "game against nature" framework and towards a more nuanced understanding of entrepreneurial decision-making, recognizing the complex interplay between

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individual skills, market dynamics, and potential economic gains.

	E	~E
E	π_1, π_2	π_1, W_2
~E	W_1, π_2	w_1, w_2

Figure 2 - Asymmetric game payoff table

This section delves deeper into the complexities of entrepreneurial decision-making, moving beyond a simple "game against nature" framework to incorporate individual skills and potential economic benefits. While payoffs in entrepreneurship remain contingent on random outcomes determined by nature, employee wages are higher when paired with an entrepreneur compared to another employee (W >w). This economic distinction shapes the dynamics of the game, depending on the specific values assigned to w,π, and W.

Parameter Influence and Evolutionary Stability: The interplay between these parameters determines the evolutionary stability of various outcomes. When $w\ 1 < \pi\ 1 < W\ 1$ and$w\ 2 < \pi\ 2 < W\ 2$, the system exhibits a similar structure to that analyzed in Section 5.1, resulting in a coexistence of entrepreneurship and employment. However, outside this parameter range, the dynamics shift significantly. Evolutionary stability can extend from both types of individuals choosing entrepreneurship ($\pi\ 1 > W\ 1, \pi\ 2 > W\ 2$) to neither type choosing it ($w\ 1 > \pi\ 1, w\ 2 > \pi\ 2$). This highlights that plural behavior can emerge not as a result of strategic interaction but due to individual strategies offering higher payoffs regardless of the choices made by others. Within these parameter ranges, dominant strategies prevail, leading to a unique evolutionary stable state in each region.

Individual Payoffs and Coordination:

The presence of individual payoffs further complicates the analysis. While it seems intuitive that individuals with comparative advantages—earning higher profits as entrepreneurs and lower wages as employees—should dominate the system, this is not always the case. As illustrated in Figure 1 and analyzed in Section 5.3, even when a configuration like $w\ 1 > w\ 2$ and $\pi\ 1 > \pi\ 2$ exists, individuals may choose strategies that are not individually optimal due to coordination challenges. Small disturbances cannot disrupt the established occupation state if a large number of individuals maintain their chosen strategies.

Roles and Individual Returns:

The game depicted in Figure 2 introduces another layer of complexity: roles. Individuals can be assigned roles (e.g., role 1 and role 2), each associated with specific payoffs depending on individual choices. This creates a dynamic where jobs earn individual returns based on the roles they occupy, further influencing evolutionary stability.

By considering these intricate interactions between individual skills, economic incentives, and strategic coordination, we gain a more nuanced understanding of the factors shaping entrepreneurial decisions within complex systems.

5-5-Incomes

This section analyzes the impact of different game structures on the expected payoffs of self-employment and employment, revealing scenarios where job earnings are equalized or diverge based on individual characteristics and strategic interactions.

Homogeneous Populations and Equal Payoffs: In games devoid of role constraints (Figure 1), homogeneous populations exhibit a propensity p to choose self-employment. This dynamic is driven by evolutionary forces acting on the propensity to enter, while heterogeneous entrepreneurs face a binary choice between these two options. Notably, in such systems, both self-employment and employment offer equal wages, irrespective of individual characteristics or strategic considerations.

Roles and Asymmetric Payoffs: Conversely, introducing roles and type distinctions can lead to divergent job earnings. When payoffs are symmetric, as seen in Figure 1, players may strategically align their choices with pre-determined environmental cues or intrinsic traits. These cues, though independent of the game's payoff structure, act as signaling mechanisms for role assignment. While these cues are subject to evolutionary pressure and can converge towards equilibrium, their presence introduces asymmetry into the system, resulting in unequal job earnings depending on an individual's assigned role.

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Collective Action and Role Coordination: In scenarios where individuals engage in collective action rather than binary interactions, the influence of roles on strategic choices diminishes. This is because coordinated actions become more complex and less reliant on pre-defined role structures. Consequently, equalized job earnings are more likely to prevail as individuals prioritize collaborative strategies over role-based distinctions.

By analyzing these distinct scenarios, we gain valuable insights into how different game structures and individual behavioral patterns shape the distribution of economic rewards within a system.

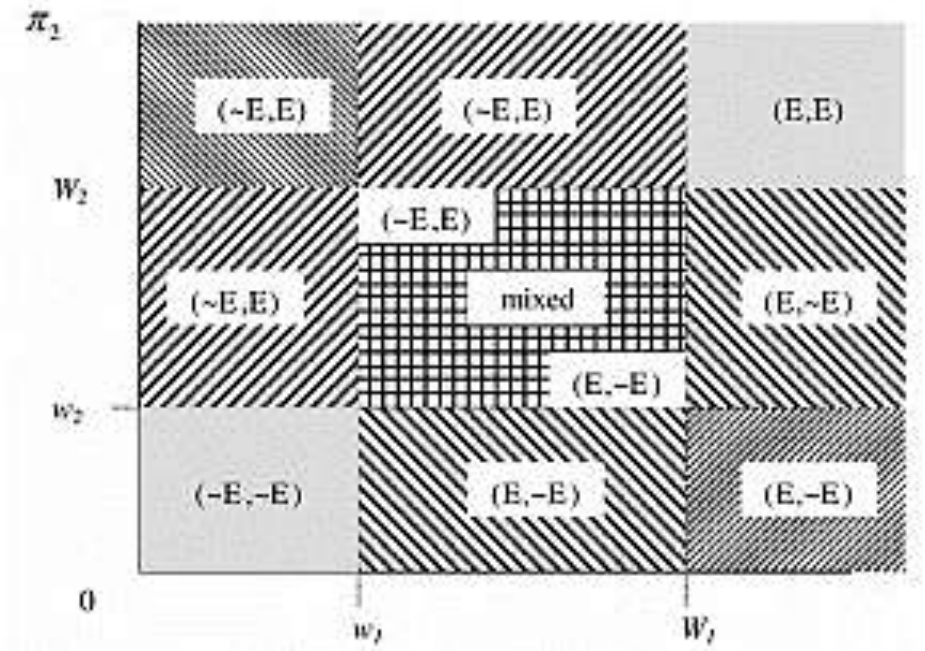

Figure 3-Possible equilibria in an asymmetric game

Individual payoffs stemming from diverse skill sets, career paths, or situational circumstances often drive contingent behavior. While solutions contingent on assigned roles may facilitate higher payoffs through coordinated action, strategies based on individual types or inherent payoffs might arise from a constrained optimization approach: "do your best given your type." When individuals select actions due to limitations imposed by characteristics or past experiences, we anticipate an imbalance in fitness outcomes.

Asymmetric Gains and Individual Skills:

In the asymmetric game depicted in Figure 2, evolutionary steady states outside the parameter range where entrepreneurship and non-entrepreneurialism are strategy substitutes (diagonalized areas in Figure 3) yield stable asymmetric gains directly attributable to individual skills. This highlights that while average earnings remain consistent across homogeneous and heterogeneous entrepreneurial populations (polymorphism), distinct average earnings likely reflect choices contingent on individual skills.

Evolution of Roles and Individual Agency:

Two key factors influence whether average earnings diverge due to skill differences: the evolutionary trajectory of roles and the extent to which individuals engage in strategic action beyond pre-defined roles.

- If roles evolve dynamically, their impact diminishes as individuals adapt their strategies based on changing circumstances and relative payoffs. This can lead to a more balanced distribution of earnings across different types.
- Conversely, when individuals "play the field" – engaging in multifaceted interactions and leveraging diverse skills – the influence of pre-defined roles weakens. Individuals become agents who actively shape their economic outcomes through strategic decision-making, leading to a greater emphasis on individual contributions and skill-based earnings disparities.

By understanding the interplay between contingent behavior, evolutionary pressures, and individual agency, we can gain deeper insights into how

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diverse factors contribute to the complex dynamics of income distribution within entrepreneurial ecosystems.

VI. EMPIRICAL EVIDENCE

While theoretical models provide valuable insights into the determinants of self-employment and employment choices, their application to real-world data presents significant challenges. The equilibrium properties examined in this paper lack asymptotic validity, and the simplified game structures used here may not fully capture the complexities faced by entrepreneurs and non-entrepreneurs in practice. Furthermore, fluctuating market conditions can significantly impact short-term earnings, making it crucial to rely on stable datasets for meaningful analysis.

Empirical Findings: Contrasting Perspectives on Entrepreneurial Returns:

Despite these limitations, empirical evidence sheds light on the relationship between self-employment and employment earnings. Hamilton (2000) analyzed U.S. data from 1983 to 1986 and found that median earnings for individuals in small businesses were 35% lower than those of employees over a decade. This finding, while accounting for various methodological considerations, suggests that non-monetary advantages like flexibility and autonomy may be key motivators for self-employment, as confirmed by entrepreneur surveys highlighting the value of being one's own boss.

Theoretical Inconsistencies: Challenges to Instrumentalist Models:

Hamilton's results challenge purely instrumental strategies based on individual skills, which are central to our theoretical framework. While we analyze expected returns, Hamilton focuses on median earnings to account for large differences within self-employed individuals. This discrepancy highlights the complexities of interpreting empirical data in the context of theoretical models.

Mixed Evidence and Future Directions:

Other studies offer conflicting perspectives. Some indicate higher initial earnings growth for male entrepreneurs in the U.S., while others reveal similar potential earnings between entrepreneurs and employees. However, entrepreneurial households consistently exhibit larger savings and assets compared to employed individuals. Further research is needed to reconcile these findings and understand the factors driving differences in earnings outcomes across various contexts.

The Homogeneity Hypothesis: A Tentative Conclusion:

Despite mixed evidence on earnings differentiation, the broad consensus against significant heterogeneity in entrepreneurship suggests that it may be premature to reject the hypothesis of individual homogeneity. Future research should continue exploring both theoretical and empirical avenues to further understand the complex interplay between individual characteristics, market conditions, and entrepreneurial outcomes.

VII. THE EVOLUTION OF ENTREPRENEURIAL PREFERENCES

From an ecological perspective, exploratory behavior is crucial for survival and productivity in dynamic environments characterized by instability, competition, and scarcity. This observation holds true for mobile organisms across diverse ecosystems. Behavioral ecologists have amassed compelling evidence demonstrating that animals inherently exhibit explorative tendencies, constantly adapting their behavior based on situational factors like hunger and predator threats.

However, understanding human preferences necessitates a different lens. While Darwinian evolution provides valuable insights into the existence of fundamental preferences that facilitated ancestral survival and reproduction, entrepreneurial choice in the modern economy presents complexities beyond simple genetic predispositions. This is where the intricate interplay between cultural evolution and innate learning mechanisms comes into play.

Reconciling Genetic and Cultural Influences: The dichotomy between biological and cultural influences raises a critical question: how are preferences for certain behaviors reconciled with their multifaceted impacts on individuals and society?

In evolutionary game theory, "fitness" is measured by the success of an individual or strategy in producing offspring, be it genetically or culturally. While in biological evolution, fitness equates to the expected number of offspring, cultural evolution measures fitness through the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 03 Mar. 2025, pp: 283-299 www.ijaem.net ISSN: 2395-5252

adoption rate of a behavior within a population over time.

For instance, entrepreneurial behavior might yield non-monetary benefits like autonomy and a sense of achievement, motivating individuals through cultural transmission and imitation. However, subjective preferences for entrepreneurship can be challenging to quantify objectively. The question arises: do these subjective preferences evolve?

Indirect Evolutionary Approach: To address this conundrum, we employ the indirect evolutionary approach, as outlined by Guth&Yaari (1992) and Guth&Kliemt (1998, 2000). This approach examines how inherent preferences influence behavior and ultimately drive evolutionary processes. Preferences indirectly shape evolution by motivating individuals towards specific actions, and their prevalence in a population is determined by the fitness of those actions.

Case Study: Entrepreneurial Decision-Making: The model presented in Figure 1 illustrates a scenario where individuals experience both positive and negative intrinsic motivations toward entrepreneurship. These subjective payoffs are depicted in Figure 4. This analysis sheds light on how individual preferences, shaped by a combination of biological predispositions and cultural influences, can drive complex decision-making processes like entrepreneurial choice.

By bridging the gap between evolutionary biology and social sciences, we gain a deeper understanding of the multifaceted factors contributing to human behavior, particularly within the dynamic realm of entrepreneurship.

	E	~E
E	π - C+m , π - C+m	π +m , w
~E	w , π +m	w , w

Image 4 - Mental repayments

This analysis delves into the evolutionary stability of entrepreneurial choices, considering both objective rewards and subjective motivational factors.

The parameter 'm' represents a purely subjective motivational factor influencing individual preferences for entrepreneurship over employment. It can take any real value, distinguishing individuals based on their intrinsic attitudes towards entrepreneurship. Those with $m > w + C - \pi$ are classified as "m+" types, exhibiting a strong preference for entrepreneurship, while those with $m < w - \pi$ are labeled "m-" types, experiencing negative motivation towards it. Importantly, due to the dominant strategy in this context, individuals do not require knowledge of others' preferences when making decisions. Our analysis investigates whether populations can reach stable states where both "m+" and "m-" types coexist. A higher proportion of "m+" types increases the entry rate into entrepreneurship, ultimately decreasing the expected payoff for "m-" types and stabilizing their population proportion. This dynamic is illustrated in Figure 4, depicting individual subjective rewards within the matrix framework.

To explore a more nuanced scenario, we consider individuals who play either E (Entrepreneurship) or ~E (Employment) with probabilities between 0 and 1. "m+" types enter the game with probability $p+ > p^*$, while "m-" types enter with probability $p- < p^*$.

A steady state emerges when both type's productive success is equal, assuming their entry probabilities (p+ and p-) align with their preferences, as depicted in Figure 4. This equilibrium is achieved when the ratio of "m+" to "m-" types, denoted by θ, reaches a specific value: $\theta^* = [\pi - p - C - w] / [(p+ - p-)C]$, which can be rewritten as $\theta^* = (p^* - p-) / (p+ - p-)$.

This direct evolutionary approach reveals that individuals with individual incentives for entrepreneurship can coexist even when objective payoffs are independent of their types. Symmetric or homogeneous payoffs do not preclude the existence of evolutionarily stable states where individual preferences play a crucial role in shaping outcomes. The sole constraint is maintaining $p- < p^* < p+$.

This analysis highlights the interplay between subjective motivations and objective rewards in driving entrepreneurial behavior. Even when external incentives are equal, individuals with differing intrinsic attitudes towards entrepreneurship can coexist in a stable population equilibrium. This finding emphasizes the importance of considering individual preferences alongside objective factors when analyzing

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 03 Mar. 2025, pp: 283-299 www.ijaem.net ISSN: 2395-5252

complex social phenomena like entrepreneurial decision-making.

VIII. FURTHER APPLICATIONS OF EVOLUTIONARY GAME THEORY TO ENTREPRENEURSHIP RESEARCH

Evolutionary game theory (EGT), originally developed within the realm of evolutionary biology, offers a unique perspective for analyzing the complex interplay between individual decision-making and emergent population-level trends over time. While its roots lie in biological evolution, EGT has proven valuable across various social science disciplines, including economics and anthropology. This paper posits that EGT holds significant potential for enriching our understanding of entrepreneurial behavior.

Towards a Comprehensive Framework:

The present study represents a preliminary foray into applying EGT to the realm of entrepreneurship. Future research endeavors could delve deeper, exploring more intricate game dynamics beyond those examined in this paper. Such explorations could shed light on various facets of entrepreneurial practices, including:

- **Regional Variations in Entrepreneurial Activity:** Investigating factors contributing to disparities in entrepreneurial activity across different regions.
- **Cluster Formation and Local Interaction Effects:** Analyzing the role of local interactions and network effects in fostering cluster formation within entrepreneurial ecosystems.
- **Evolution of Diverse Human Capital Patterns:** Examining how evolutionary pressures shape the distribution and evolution of skills and knowledge within entrepreneurial populations.

Bridging Individual Choices and Population-Level Dynamics:

EGT's ability to bridge individual decision-making with population-level outcomes makes it particularly suitable for unraveling the complexities of entrepreneurship. Consider, for example:

- **Entrepreneurial Agglomeration:** Existing literature on entrepreneurial agglomeration often portrays a dynamic positive feedback loop driven by complementary solutions, shared knowledge, and network phenomena (Minniti, 2005). These models typically assume static regional boundaries and reversible decisions. However, incorporating migration of individuals and ideas between regions, coupled with social learning mechanisms as explored in Henrich& Boyd's work, could provide a more nuanced understanding of agglomeration dynamics.
- **Skill Specialization and Entrepreneurial Choice:** Lazear (2004) demonstrated that under specific conditions, individuals with balanced skill sets are more likely to choose entrepreneurship compared to those specializing in a single domain. This finding highlights the crucial role of market valuation of entrepreneurial talent in shaping individual choices. EGT frameworks can be employed to model the strategic decision-making involved in choosing between general and specialized skill sets, demonstrating that general strategies tend to exhibit greater resilience across varying environmental conditions.
- **Genetic Influence on Entrepreneurial Traits:** Recognizing the evolutionary origins of human behavior, EGT offers a valuable lens for exploring the potential genetic underpinnings of entrepreneurial traits. While traditional game theory struggles to explain the selection pressures favoring specific genetic predispositions, EGT's integration of biological and cultural evolution provides a framework for understanding how genes and culture interact in shaping entrepreneurial tendencies.

By bridging individual agency with population-level dynamics, EGT offers a powerful framework for unraveling the complexities of entrepreneurship, paving the way for novel insights into its origins, evolution, and future trajectory.

IX. CONCLUSION

This paper challenges the prevailing assumption of entrepreneurial heterogeneity within existing theories of entrepreneurship. By employing an evolutionary game-theoretic approach, we demonstrate that the coexistence of self-employment and employee strategies can be explained without invoking fixed traits distinguishing entrepreneurs from non-entrepreneurs.

Traditionally, entrepreneurship literature has often portrayed entrepreneurs as a distinct group, possessing unique characteristics (Shane &Venkataraman, 2000). This notion of entrepreneurial heterogeneity necessitates specific

attributes driving the division between those who choose self-employment and those who remain employees. However, our analysis reveals that such a set of predetermined traits is not a prerequisite for understanding the observed co-existence of these strategies. While individuals undoubtedly exhibit genetic and behavioral diversity, this paper argues that the core question lies in whether specific traits inherently dictate entrepreneurial decisions.

Our research analyzes two distinct games capturing the essence of the entrepreneurial phenomenon. These analyses reveal equilibrium conditions under which both self-employment and employment coexist, suggesting that entrepreneurship persists even in the absence of strategy complementarities and individual choice based on fixed characteristics.

Furthermore, we highlight that the mere co-existence of self-employment and employment does not necessarily imply heterogeneity in entrepreneurial or individual skills. Empirical evidence regarding average earnings between entrepreneurs and non-entrepreneurs remains mixed, with some studies suggesting minimal differences (United States). Therefore, dismissing the hypothesis of homogeneous entrepreneurial traits based solely on observed coexistence may be premature.

This theoretical challenge carries significant implications for various facets of entrepreneurship research, including education, practice, and policy:

- **Research:** Focusing on the diversity of traits and behaviors within the entrepreneurial population alongside situational variables that characterize entrepreneurial trajectories becomes crucial. Understanding the interplay between cultural processes and genetic evolution in shaping entrepreneurial behavior requires further investigation.
- **Education:** Entrepreneurship education should shift its focus from solely emphasizing inherent psychological traits towards equipping individuals with practical skills for navigating the complexities of self-employment, such as transaction creation and risk mitigation.

Recognizing that the space for improving entrepreneurial activity is inherently limited by the strategic nature of self-employment and employment, policymakers should prioritize addressing institutional barriers hindering potential entrepreneurs.

By providing a novel framework rooted in evolutionary game theory, this paper sheds light on the complex interplay between individual choices and population-level dynamics in shaping entrepreneurial behavior. This theoretical contribution encourages a shift towards a more nuanced understanding of entrepreneurship beyond the traditional lens of inherent heterogeneity.

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