# Exit Dynamics in Quebec's Organic Farming*

Komla Avoumatsodo[†1] and Moustapha Thiam[‡2]

[1]University of Northern British Columbia, 3333 University Way, Prince George, BC, Canada, V2N 4Z9
[2]Université du Québec à Montréal, 315 rue Sainte-Catherine E, Montreal QUEBEC H2X 3X2

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**Abstract**

This paper examines the dynamics of adoption and retention in Quebec's organic farming sector and their policy implications. Using certification records from *'Portail Bio Québec'*, we document strong entry but high early exit—particularly within the first five years—which constrains net growth. The results show that survival varies systematically with farm age, certification body, and the structure of production—specifically, the types of products certified and the extent of diversification. Building on these patterns, we develop a dynamic model of farmers' regime-switching decisions, calibrated to observed exit rates, which identifies two producer types: impatient farmers, who tend to exit early in response to idiosyncratic pest shocks, and patient, forward-looking farmers, who remain in organic production over time despite such risks. Policy simulations indicate that a post-certification subsidy of \$100 per hectare reduces first-year exits by 55.4%, while an 80% pesticide tax lowers them by 43%. In contrast, a 1% increase in pest severity raises first-year exit rates by 25%. Overall, the findings suggest that long-term retention depends not only on financial incentives but also on behavioral heterogeneity and ecological risk. Effective policy design should therefore combine transitional support with measures that strengthen resilience and favor forward-looking producers.

*Keywords*: Organic farming, adoption and retention, farm exit dynamics, pesticide taxation, subsidies.

JEL Classification: Q12, Q18, Q57, Q58

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†Corresponding author, Email: komla.avoumatsodo@unbc.ca, +1 250 960 6491

‡Email: thiam.moustapha@courrier.uqam.ca

# 1 Introduction

Over the past two decades, organic farming has established itself as one of the main alternatives to conventional agriculture. Valued for its ecological practices, its non-dependence on synthetic inputs, and its potential contribution to the sustainability of food systems, the organic sector has attracted growing interest from policymakers, researchers, and consumers. In many countries, its expansion has been supported by financial incentives, certification schemes, and consumers' willingness to pay a price premium for organic products (Veldstra et al. 2014, Jaime et al. 2016). Yet, despite strong demand and favorable policies, one striking feature persists: high exit rates. In Quebec, they fluctuate between 5% and 7% per year over the period 2021–2024. Similar observations have been made in other contexts: in Ireland, for example, Läpple (2010), Läpple & Kelley (2013) report high abandonment rates in the drystock sector. More generally, a significant proportion of organic farms give up certification within the first years of adoption, creating a fragile equilibrium in which new entries are largely offset by frequent exits. This high turnover raises fundamental questions about the long-term sustainability and resilience of organic farming.

The problematic nature of organic farming exits is particularly evident in Quebec, which represents a distinctive case within the Canadian context. With nearly 8.4% of its agricultural enterprises certified as organic, Quebec ranks well above the national average and accounts for the majority of Canada's organic fruit and vegetable output.[1] The province has implemented strong institutional and policy support, including certification assistance, subsidies, and targeted programs under the *'Prime Vert'* plan. Despite these favorable conditions, our descriptive analysis reveals a paradox: while Quebec experiences continuous entry into organic certification, exit rates remain elevated, especially during the first five years after adoption. This turnover constrains net growth and signals structural weaknesses that policy support has not fully addressed. Understanding why certified farms exit, and under what conditions they are more likely to persist, is therefore crucial for designing policies that can secure the future of organic farming in the province.

The central question guiding this paper is: what explains the high rate of exits among organic farms, and what policies can strengthen retention in the sector? Addressing this question requires going beyond descriptive statistics to combine econometric evidence with a structural modeling framework capable of capturing farmers' dynamic choices under uncertainty. Our study brings together rich certification data, empirical analysis, and theoretical modeling to offer a comprehensive perspective on the determinants of exit and the potential effects of policy interventions.

We begin by constructing a novel dataset from the *'Portail Bio Québec'*[2], which records all certified organic enterprises in the province along with information on entry and exit events, product certification categories, and certifying bodies. Covering the years 2023 and 2024, this dataset allows us to document patterns of adoption, regional disparities, and product specialization. We complement this descriptive overview with a systematic examination of entry and

[1] Quebec concentrates the bulk of Canada's organic horticulture, with roughly four-fifths of organic fruit acreage and nearly two-thirds of organic vegetable acreage located in the province.

[2] https://portailbioquebec.info/

exit flows, highlighting the fragile equilibrium of the sector: a growing number of certifications offset by persistent exits, concentrated in the early years after adoption.

The second step of our analysis employs econometric methods to identify the key determinants of exit probability. Using a panel logit model with random effects, we estimate how farm characteristics—such as age since certification, certifier, product type, and regional location—affect the likelihood of exit. The econometric results show that farm age plays a decisive role, with the risk of exit being highest in the first four to five years of certification. Certification body also matters: farms certified by *Ecocert Canada* display lower exit rates than those under *Québec-Vrai*, suggesting differences in institutional support and market access. In terms of product categories, maple and livestock enterprises appear more resilient, while wild-harvest producers are disproportionately vulnerable. Regional differences further confirm the role of localized support structures and market conditions. Together, these findings provide the first systematic evidence on the determinants of organic exits in Quebec.

While econometric analysis identifies the correlates of exit, it cannot fully capture the underlying decision-making process. To address this, we develop a dynamic theoretical model in which farmers choose between conventional and organic regimes, accounting for price premiums, environmental shocks, and heterogeneity in time preferences. The model formalizes the intuition that patient, forward-looking farmers are willing to endure short-term yield losses from severe idiosyncratic pest shocks to benefit from future price premiums and more favorable outcomes, whereas impatient farmers are more likely to revert to conventional farming. By embedding stochastic shocks, such as pest outbreaks, the model also captures the heightened risks faced by organic producers in the absence of chemical protections.

To align the model with observed exit dynamics, we calibrate its parameters using empirical exit rates from the certification dataset provided by *'Portail Bio Québec'* and input cost and price data from the *'Centre de Référence en Agriculture et Agroalimentaire du Québec'* (CRAAQ). The calibration identifies three fundamental forces shaping the evolution of organic farms: heterogeneity in time preferences, the composition of producer types, and the persistence of yield shocks. The estimated time preference parameters—approximately 0.70 for impatient producers and 0.95 for patient producers—indicate pronounced differences in intertemporal behavior. Patient producers, who represent roughly one quarter of initial entrants, place greater weight on future returns and sustain production even when short-run profitability declines. Impatient producers, by contrast, tend to exit early when expected gains do not materialize.

The calibrated model successfully reproduces the observed life-cycle pattern of exits: about one in eight organic farms leaves within the first year, followed by a gradual decline as the sector stabilizes. This dynamic reflects the joint influence of behavioral heterogeneity and environmental risk. Yield shocks, modeled as a Markov process with productivity differences of nearly 40% between favorable and adverse pest conditions, generate persistent income volatility that disproportionately affects impatient farmers. Over time, the sector self-selects toward more patient producers, who constitute the resilient core of long-term participants.

Building on this baseline, the analysis proceeds in three stages of policy evaluation. The first focuses on direct income support. A one-year post-certification subsidy of \$100/ha[3] reduces first-

[3] We use a \$100/ha subsidy for counterfactual analysis, consistent with Prime-Vert support for cereals, oilseeds,

year exits from 12.1% to roughly 5.4%, retaining about 55.4% of entrants who would otherwise leave. Extending support to ten years amplifies this effect, with cumulative exits falling to about 63.7% compared to nearly 90.6% in the baseline. Yet, once the assistance is withdrawn, many producers revert to conventional production, highlighting the role of subsidies in offsetting short-term organic yield losses.

The second stage examines a price-based environmental instrument—an 80% pesticide tax consistent with Quebec's Sustainable Agriculture Plan (SAP)[4]. By increasing the cost of conventional production, the tax discourages short-term reversions and reduces first-year exits to about 6.9%, retaining 43% of farmers who would otherwise leave within the first twelve months. Over time, as impatient producers leave the sector, the gap between the tax-calibrated exit distribution and the baseline narrows; after ten years, roughly 22% of total entrants who would have exited are retained. Compared to the $100 per ha per year subsidy, the tax retains about 5% fewer farmers after ten years, yet both policies foster durable compositional change by selecting producers with higher long-term commitment.

The final stage considers a stress scenario with intensified pest pressure, represented by a 1% increase in yield losses across all pest shock states—equivalent to a 1% decline in expected average yields. Under this condition, even patient farmers face higher exits, as the permanent productivity loss cannot be offset. First-year exits rise by roughly 25% relative to the baseline, highlighting the need for complementary mechanisms—such as crop insurance and pest monitoring systems—to mitigate the effects of environmental shocks.

Taken together, the analysis demonstrates that the sustainability of organic farming hinges not only on price-based incentives but also on the interaction between behavioral heterogeneity and ecological persistence. Policies that merely stimulate entry or short-term profitability are unlikely to secure long-term retention unless they internalize farmers' time preferences, biological risks, and the evolving structure of the sector.

**Related Literature.** The dynamics of entry and exit in agriculture have long attracted scholarly attention, with a growing body of work emphasizing the distinctive challenges faced by organic producers. Despite its steady global expansion, organic agriculture continues to exhibit high turnover rates, raising fundamental questions about the long-term viability of this production system. Understanding the mechanisms underlying these exits is essential to assess the sustainability of organic farming as both an economic and environmental strategy.

A first body of research underscores the economic and institutional constraints that shape exit behavior. Higher production costs, price volatility, and the administrative complexity of certification increase the likelihood of abandonment (Mishra et al. 2014, Dong et al. 2016, Läpple 2010, Goetz & Debertin 2001). Limited access to credit and inadequate policy support further weaken farmers' capacity to remain in operation (Kitenge 2022, Hartarska et al. 2022). Moreover, when off-farm income becomes a more stable source of livelihood, households often withdraw from certification programs (Johansson et al. 2025).

A second strand of literature highlights the structural and policy-related determinants of

and legumes.

[4]Séguin & Thiam (2025) use a computable general equilibrium (CGE) model calibrated to the Quebec economy and find that an 80% tax on pesticides reduces their use by about 12%, consistent with the SAP target.

persistence. Agricultural reforms—such as the Common Agricultural Policy (CAP)—have been shown to affect organic producers' decisions by altering relative incentives (Jaime et al. 2016). Market instability and competition with conventional farming also generate pressures that discourage long-term participation (Läpple & Kelley 2013). Broader studies on farm dynamics provide valuable insights into entry–exit patterns (Chen et al. 2022), but they generally overlook the specific institutional and ecological features that distinguish organic farming from conventional systems.

Methodologically, several approaches have been employed to study farm exits. Discrete choice models estimate how farm and household characteristics influence exit probabilities (Goetz & Debertin 2001, Mishra et al. 2014), while duration and cohort analyses reveal survival patterns across age groups and regions (Gale 2003, Läpple 2010). Technical efficiency and scale effects are also key predictors of persistence, especially in dairy systems (Dong et al. 2016). Yet, these approaches remain largely static, failing to capture the dynamic adjustment processes that organic farmers undergo during and after certification.

Recent research has expanded the analytical scope by incorporating environmental and policy shocks. Declines in government support are associated with higher exit rates (Mishra et al. 2014), while climate variability and pesticide-reduction measures intensify production risks (Zorn & Zimmert 2022, Läpple 2010). The broader literature on environmental regulation confirms that the design of public policy crucially shapes incentives for sustainable adoption (Acemoglu et al. 2012). However, the joint influence of behavioral factors—such as time preferences—and biophysical risks on organic farm exits remains insufficiently explored.

Our paper builds on two complementary strands of research on the ecological transition in agriculture. Leblanc et al. (2021) analyze soybean producers in the Brazilian Amazon and show that high discount rates and risk aversion significantly constrain the adoption of ecological practices. Their findings suggest the role of time preferences in shaping sustainability decisions—an element that we explicitly integrate into our dynamic model by distinguishing between patient and impatient farmers. In parallel, Piovesan (2019) study agri-environmental policies in Québec and demonstrate that while subsidies promote conversion to organic farming, they often fail to ensure long-term retention when profit margins remain unstable. We extend this perspective through a unified behavioral and structural framework in which intertemporal preferences and pest shocks interact with economic incentives to explain the persistence and exit dynamics in Québec's organic sector.

Within this broader context, our study contributes to the literature in four main ways. We focus exclusively on organic producers, rather than treating them as part of aggregate farming exit analyses (Kitenge 2022, Hartarska et al. 2022, Chen et al. 2022); we encompass the full range of organic production systems, moving beyond sector-specific studies such as dairy (Dong et al. 2016); we provide new empirical evidence from Québec, a leading yet understudied region in Canadian organic agriculture; and we develop a dynamic framework that links exit decisions to farm age, intertemporal preferences, and pest shocks. This integrated approach allows us to evaluate how farmers adjust over time and to assess the effectiveness of policy instruments in mitigating exit risks.

By bridging behavioral, structural, and environmental dimensions, this work advances the understanding of organic farming resilience under market uncertainty and informs the design of policies aimed at sustaining the sector's long-term viability.

**Outline.** The remainder of the paper is structured as follows. Section 2 introduces the data and descriptive analysis of certification patterns in Quebec. Section 3 presents the econometric framework used to estimate the determinants of organic exits. Section 4 develops the dynamic theoretical model of regime-switching. Section 5 describes the model calibration to the data and reports the results of policy analysis. Section 6 concludes by summarizing the main findings and drawing implications for the design of agricultural policies that can enhance the resilience of the organic sector.

## 2 Patterns and Dynamics of Organic Farming

Organic agriculture has gained growing international attention as a sustainable alternative to conventional farming. However, its adoption remains uneven across countries and regions, shaped by differences in policy support, environmental conditions, and market development. To contextualize Quebec's position within this global landscape, we begin by examining international variations in the extent of land dedicated to organic farming. We then turn to the structure of Quebec's organic sector, exploring the distribution of certifications across certifiers, regions, and product categories. Finally, we analyze the dynamics of participation by investigating the patterns of entry and exit among certified enterprises. Together, these analyses provide a comprehensive view of how organic farming is evolving in Quebec and the factors that may influence its long-term viability.

### 2.1 Global Variations in Organic Farming

Organic agriculture is grounded in ecological and sustainable principles that seek to produce food while preserving natural resources. By prioritizing biological processes and eliminating the use of synthetic pesticides and fertilizers, it supports biodiversity through practices such as crop diversification and rotation, which contribute to balanced and resilient ecosystems. Moreover, organic farming promotes sustainable soil management, enhancing soil fertility and reducing erosion. The absence of synthetic inputs also helps mitigate water pollution, while adherence to natural growth cycles minimizes environmental disruptions. Importantly, by limiting exposure to toxic residues and reducing the risk of antimicrobial resistance, organic methods offer improved food safety and quality (Średnicka Tober et al. 2016). Despite these environmental advantages, organic agriculture faces several constraints. Yields are typically lower than those achieved through conventional methods, posing challenges in meeting growing global food demand. This reduced productivity often necessitates greater land use to achieve equivalent output levels. In addition, organic systems rely heavily on locally available inputs such as compost, which may be limited or unevenly distributed across regions. Organic crops are also more vulnerable to pests and diseases, increasing the risk of harvest losses. Furthermore, production costs are generally higher due to labor-intensive techniques and restrictions on cost-effective synthetic inputs.

Given these trade-offs, it is crucial to examine the global distribution and evolution of organic

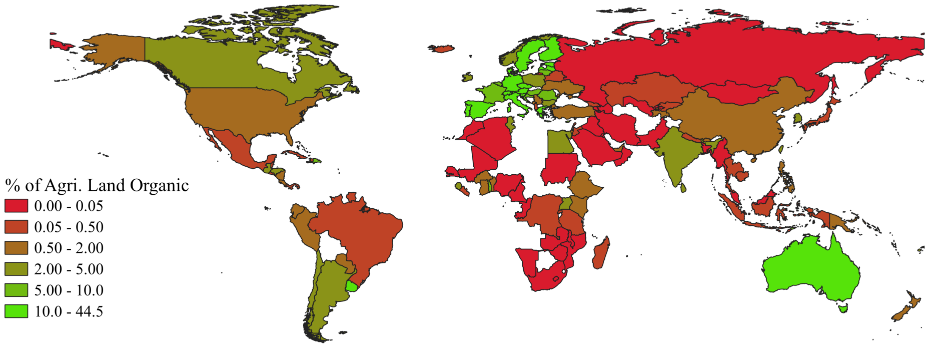



**Figure 1:** Percentage of Total Agricultural Land Devoted to Organic Farming (2023)

*Notes:* This figure shows the percentage of agricultural land in each country that is dedicated to organic production in 2023, based on FiBL data.

agricultural land. Understanding where and how organic farming is expanding can shed light on its broader implications for sustainable food systems and inform policy efforts aimed at scaling up environmentally friendly practices.

Data from the Research Institute of Organic Agriculture (FiBL) reveal substantial cross-country disparities in the adoption of organic farming, particularly in terms of land area devoted to organic practices. Australia leads by a wide margin, with approximately 53 million hectares under organic management, followed by India (4.4 million ha), Argentina (4 million ha), and Uruguay (3.5 million ha). In contrast, Canada has a more modest footprint, with about 1.3 million hectares dedicated to organic agriculture.

However, a different picture emerges when considering the share of total agricultural land allocated to organic farming (see Figure 1). In relative terms, Liechtenstein ranks first, with 44.5% of its agricultural land under organic cultivation, followed by Austria (27%), Uruguay (25%), and Estonia (22%). Canada's share stands at just 2%, well below the European Union average of approximately 4%.

These differences highlight the influence of national agricultural policies, institutional support, and market incentives on the adoption of organic practices. Countries with a higher proportion of organic land have often implemented comprehensive support frameworks—including subsidies, training, and market development strategies—whereas those with more limited organic acreage may face structural and policy-related barriers to growth.

Significant variation in the adoption of organic farming practices also exists within Canada, particularly across provinces. According to Statistics Canada data for 2021, provincial adoption rates differ markedly. Quebec emerges as a national leader, with 8.4% of its agricultural enterprises devoted to organic production—substantially exceeding the rates observed in other provinces. This strong uptake reflects a combination of factors, including supportive provincial policies, targeted financial incentives, rising consumer demand for organic products, and increased public awareness of the environmental and health advantages associated with organic farming.

In contrast, other provinces such as Manitoba, Saskatchewan, Alberta, and Nova Scotia ex-

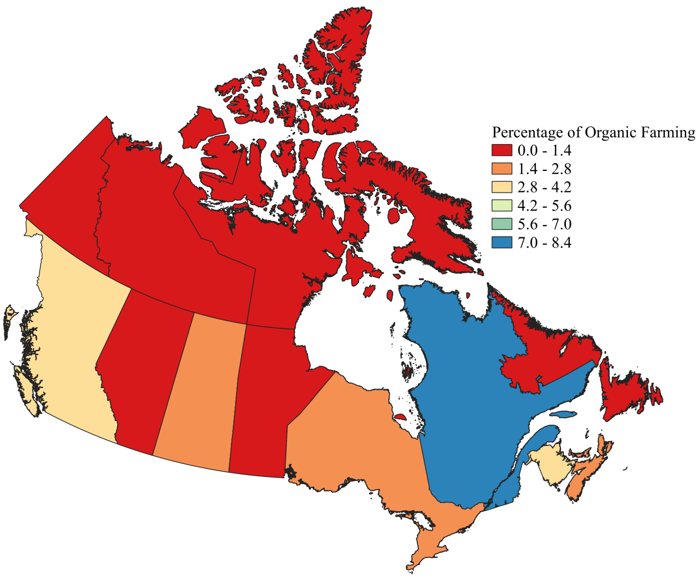



**Figure 2:** Percentage of Farms in Organic Production by Canadian Province (2021)

*Notes:* This figure shows the percentage of total agricultural firms engaged in organic production in each Canadian province in 2021, using data from Statistics Canada.

hibit significantly lower adoption rates (see Figure 2). This discrepancy may result from differences in agricultural policies, availability of financial and technical support, economic priorities, and regional farming traditions.

To further illustrate Quebec's leadership in organic agriculture, we consider the case of organic fruit and vegetable production, which represents a substantial segment of the sector. According to Statistics Canada, the total cultivated area for fresh organic fruits and vegetables in Canada amounts to approximately 13,000 hectares and 6,000 hectares, respectively. Remarkably, Quebec alone accounts for 82% of the organic fruit production area and 65% of the organic vegetable production area nationwide. These figures underscore the province's dominant role in the national organic sector.

Despite this dominance, further analysis is needed to assess the long-term sustainability of Quebec's organic farming sector. A closer examination of entry and exit dynamics, along with the factors influencing producers' participation and retention, is essential to gaining a comprehensive understanding of the sector's resilience and its prospects for future development.

## 2.2 Structure of Organic Agriculture in Quebec

This section explores key dimensions that characterize the development of organic farming in Quebec. It begins by examining the geographic distribution of certified organic operations, followed by an analysis of certification patterns across crop categories.

**Data Source.** Studying patterns in Quebec's organic sector requires detailed certification data. Our data comes from the *'Portail Bio du Québec'*, which compiles information on all firms holding an organic certification, as well as new entrants and enterprises that have exited the sector within the last 12 months in Quebec. This dataset provides specific characteristics about each enterprise, including its name, address, certification start date, certification end date (if it has exited the sector), and the categories of products for which it is certified.

Since data on business exits is only available for the last 12 months, we conducted two data extractions to obtain information covering two full years of study. The first data extraction was performed in January 2024 to capture exits that occurred over the preceding twelve months, while the second extraction will be conducted in February 2025 to gather data on exits in 2024. However, due to this methodology, we lack exit data for a few days in January 2024. Consequently, for analytical consistency, we define the 2024 study period as February 2024 to February 2025.

This approach allows us to construct a comprehensive dataset that accounts for organic certification dynamics over time, while acknowledging minor data gaps due to system limitations in reporting exit information.

**Market Shares of Organic Certifiers and Regional Context in Quebec.** Organic certification in Quebec is overseen by several accredited organizations responsible for verifying compliance with established organic standards. Figure A.1 in Appendix A shows the distribution of certifications among certifying bodies in 2023 and 2024.

The data reveal a highly concentrated certification landscape. Ecocert Canada dominates the market, accounting for 86% of all certifications in 2023 and increasing slightly to 86.2% in 2024. Québec-Vrai follows as the second-largest certifier, with a share of 11.8% in 2023 and 11.6% in 2024. These figures reflect a growing centralization of certification services around a single dominant provider.

Other certifiers—such as Pro-Cert Organic, Letis S.A., QAI Inc., and TransCanada Organic Certification Services—together account for less than 2% of the total market in both years. Their marginal presence may stem from a limited operational footprint in Quebec, lower brand recognition, or less tailored services compared to the leading certifiers. This high degree of market concentration presents both opportunities and challenges. On one hand, a dominant certifier may promote consistency and simplify procedures for producers. On the other hand, limited competition may reduce the diversity of available services, restrict choice for agricultural enterprises, and influence certification costs or conditions.

Figure A.2 (see Appendix A) displays the regional distribution of certified organic enterprises in Quebec for the years 2023 and 2024. In both years, Chaudière-Appalaches leads with the highest number of certified products, followed by Estrie, Montérégie, Bas-Saint-Laurent, and Centre-du-Québec. These five regions consistently account for more than 66% of organic certifications, underscoring their central role in the province's organic agriculture landscape.

Their prominence likely reflects a combination of factors, including a historically strong agricultural base, favorable agroecological conditions, and a more advanced adoption of organic practices. In addition, these regions often benefit from more developed institutional support structures, such as regional advisory services and producer networks, which can facilitate certification and support long-term organic production.

The observed regional disparities in organic certification likely reflect differences in access to resources, infrastructure, and market opportunities across Quebec. Recognizing these spatial patterns is important for identifying areas where targeted support could help strengthen the presence of organic agriculture and foster more balanced sectoral development.

**Organic Certification by Crop Category in Quebec.** We now turn to a complementary analysis by product category to examine whether similar patterns emerge across types of production. Figure 3 presents the share of each product category in total organic certifications in Quebec for 2023 and 2024. The data reveal a high degree of specialization, with organic production concentrated in a limited number of key categories. This concentration likely reflects both prevailing market demand and structural factors that influence the organization of organic farming in the province.

In both 2023 and 2024, plant-based crops represent the largest share of certified enterprises—45.3% and 44.3%, respectively. This dominant position highlights the central role of crop production in Quebec's organic sector, supported by sustained consumer demand for plant-based and environmentally sustainable food options. Maple products rank second, comprising 21.4% of certifications in 2023 and rising to 23.2% in 2024. Notably, this is the only category to record a net increase in certifications, suggesting a dynamic response to both domestic and international demand for organic maple goods.

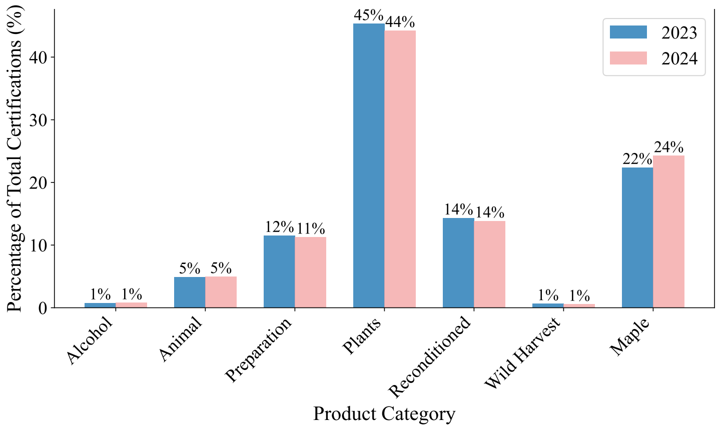



**Figure 3:** Certified Firms as Percentage of Total by Category in Quebec (2023 vs 2024)

*Notes:* This figure shows the distribution of certified organic enterprises by product category in Quebec, expressed as a percentage of the total in 2023 and 2024. Product categories include: alcoholic beverages (e.g., wine, cider, beer), animal production (including meat, dairy, and eggs), food preparation (processed organic foods), plant-based crops (such as fruits, vegetables, and grains), reconditioned products (organic items that are repackaged or relabeled without further processing), wild harvest (uncultivated products such as wild berries or mushrooms), and maple (syrup and other derivatives).

In contrast, several categories remain marginal. Certifications in wild harvest and alcoholic beverages account for less than 1% of the total and have not grown significantly over the period. Similarly, food preparation and reconditioned products exhibit limited movement, which may indicate saturation, niche market constraints, or operational barriers such as complex regulatory requirements or limited infrastructure.

## 2.3 Dynamics of Participation in Quebec's Organic Agriculture

We now examine the dynamics of entry and exit in Quebec's organic farming sector. We describe how participation in the sector has evolved over time and highlight differences across regions and types of production. These patterns offer insights into the turnover of organic farms and the heterogeneity of farm trajectories across the province.

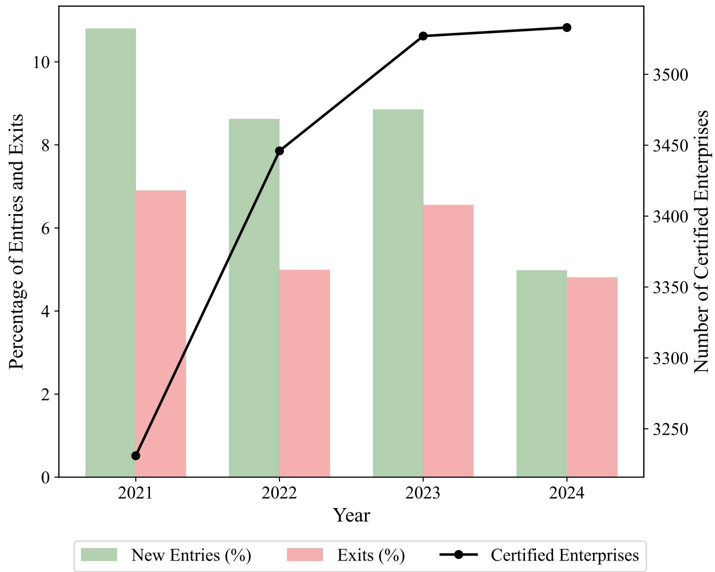



**Figure 4:** Evolution of Certified Organic Enterprises in Quebec

*Notes:* This figure presents the number of certified firms from 2021 to 2024 (shown by the black solid line, with values on the right-hand vertical axis), as well as the percentage of new entries and exits relative to the total certifications each year (with values indicated on the left-hand vertical axis).
*Data Source*: Portail Bio Québec, https://portailbioquebec.info/

Quebec has made significant progress in adopting more sustainable farming practices. However, as illustrated in Figure 4, the sector's growth potential remains constrained by a high exit rate. An analysis of certified organic enterprises shows that, despite growth in the number of certified farms, substantial fluctuations in entries and exits reflect ongoing challenges to sustaining growth in the organic sector.

The data suggest a complex pattern: significant new entries indicate sustained interest in organic agriculture, but high exit rates reveal ongoing challenges related to retention. This tension between expansion and attrition limits the sector's capacity for stable growth. In effect, new entrants often replace outgoing farms, resulting in limited net growth and reinforcing the view that organic farming in Quebec remains in a fragile equilibrium.

Importantly, Figure 4 hides significant heterogeneity in entry and exit dynamics across regions and product categories. As illustrated in Figure A.3 (Appendix A), data disaggregated by region for 2023 and 2024 reveal that in 7 of Quebec's 17 administrative regions, exits exceeded entries. Across most regions, entry and exit trends appear to move in parallel, suggesting a pattern of turnover rather than sustained expansion. This dynamic may reflect a sector still in transition, where new farms enter but often do not persist long enough to contribute to long-term growth.

These patterns are concerning, particularly in regions with large numbers of certified farms but also elevated exit rates. Such conditions may signal structural constraints—economic, institutional, or logistical—that limit producers' ability to remain in the sector. Factors such as cost pressures, market volatility, and the administrative burden of maintaining certification likely play a role (Uematsu & Mishra 2012).

**Entry and Exit by Product Category.** Figure 5 illustrates the net change in certified enterprises by product category, measured as the difference between entries and exits in 2023 and 2024. The data reveal a striking trend: with the sole exception of maple products, all other categories recorded a negative balance, meaning more certifications were terminated than granted. This decline indicates increasing challenges in maintaining certification across most product types, despite ongoing interest in organic agriculture. The resilience of the maple sector may reflect its strong market demand, well-established infrastructure, and relatively stable production conditions, highlighting the uneven nature of challenges faced by different segments of the organic sector.

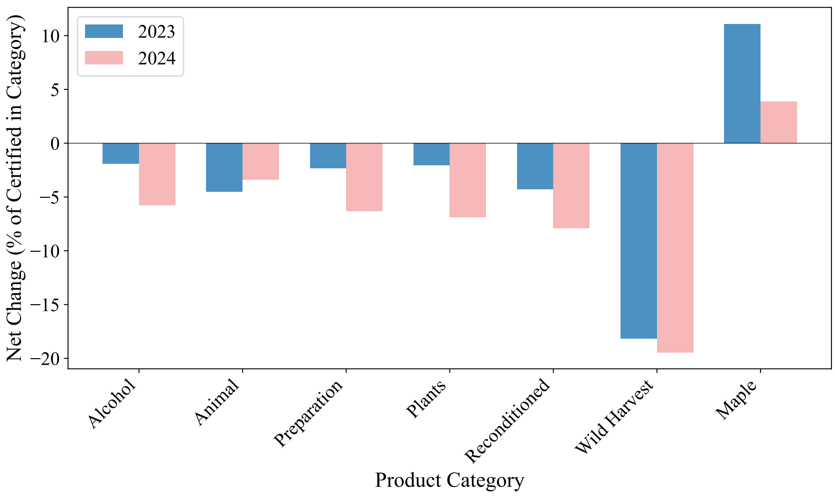
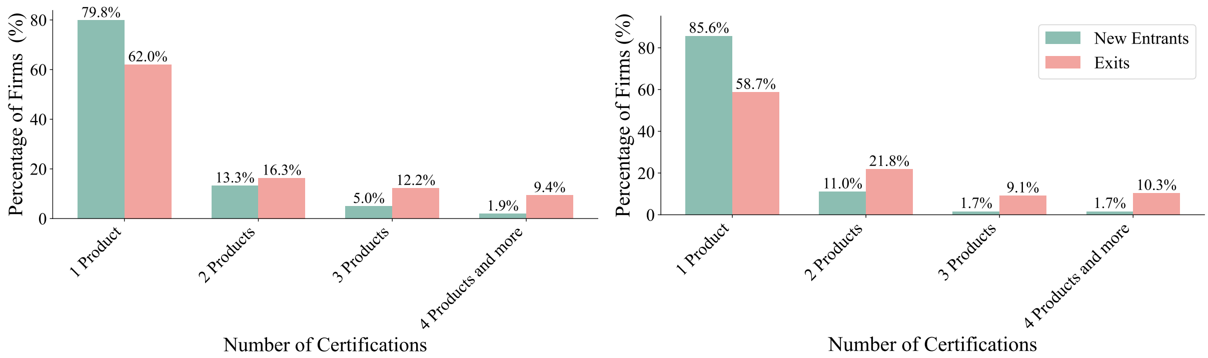



**Figure 5:** Net Change as Percentage of Certified Firms by Category

*Notes:* This figure shows the net change in the number of certifications, expressed as a percentage of total certifications, for each product category in 2023 and 2024.

This decrease in product-level certifications may seem counterintuitive, particularly given Figure 4, which shows a modest rise in the total number of certified enterprises. The discrepancy is clarified by the certification structure: a firm certified for multiple products that loses certification for one remains recorded as an active certified enterprise, even though product-level losses accumulate. Second, while some enterprises exit the organic sector by relinquishing certification for a single product, others typically abandon all certified products. In contrast, most new entrants begin with a narrow focus, often certifying only a single product in their first year.

To better understand this asymmetry, Figure 6 presents the number of enterprises entering and exiting in 2023 and 2024, disaggregated by the number of certified products. The data show that the majority of new entrants in both years certified only one product, and the number of these single-product entries exceeded the number of exits in the same category. However, a different picture emerges for enterprises with two or more certified products: in these categories, exits consistently outnumber entries. This asymmetry in entry and exit patterns helps explain why, for many product categories, the number of certifications granted is lower than the number of certifications lost. Next, we analyze the duration firms remain active before exiting. Examin-




**(a)** 2023 **(b)** 2024

**Figure 6:** Entries and Exits by Number of Products

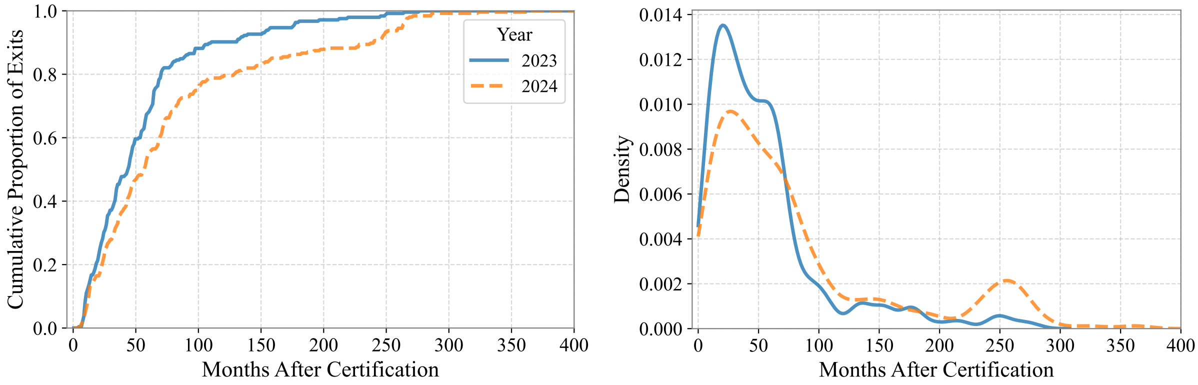
*Notes:* This figure presents the distribution of firms by the number of certified product categories at the time of entry into or exit from the organic sector in 2023 and 2024. Panel (a) shows data for 2023, and Panel (b) for 2024. Green bars indicate the percentage of new entrants certified in $n$ product categories, calculated as a share of total entrants. Orange bars represent the percentage of firms exiting the sector with $n$ certified product categories, calculated as a share of total exits. The figure illustrates how the degree of product diversification varies between entering and exiting firms across the two years.

ing survival times can reveal early-stage challenges and difficulties in sustaining diversification. This temporal perspective helps identify critical periods for targeted support to reduce attrition and enhance sectoral stability.

**Time in the Organic Sector Before Exit.** Figure 7 shows the time that certified enterprises remained in the organic sector before exiting, for 2023 and 2024. The density distribution (Figure 7b) highlights that exits are most frequent shortly after certification, underscoring the vulnerability of younger enterprises.

The cumulative distribution (Figure 7a) further illustrates this pattern: in both years, over 50% of exits occur within the first 50 months (just over four years), as indicated by the steep initial rise of the curve. Beyond roughly 60 months (about five years), the slope of the cumulative curve becomes markedly flatter, indicating that longer-established farms are less likely to exit. Nonetheless, the curve continues to rise gradually past 250 months (over 20 years), showing that attrition also occurs among mature operations, potentially due to retirement, succession issues, or strategic shifts back to conventional production.

The predominance of early exits underscores the need for targeted policy interventions. Supporting new entrants through advisory services, financial instruments, or peer networks could strengthen early-stage survival, enhancing retention and contributing to the long-term stability of Quebec's organic sector. While the descriptive results reveal clear patterns in exit timing and frequency, we now proceed to an econometric analysis to better assess the contribution of each factor to the dynamics of certifications over time.




**(a)** Cumulative Exits

**(b)** Density

**Figure 7:** Distribution of Time Spent in the Organic Sector Before Exit

*Notes:* This figure shows the distribution of time spent in the organic sector—measured in months—by enterprises that exited in 2023 and 2024. Panel (a) presents the cumulative proportion of firms exiting the sector by age, measured in months since initial certification, with the solid blue line representing 2023 and the dashed orange line representing 2024. Panel (b) shows the corresponding density.

# 3 Econometric Analysis

This section examines whether the correlations identified in Section 2 are statistically significant and explores the relative importance of each factor in explaining exit patterns. We begin by presenting the empirical model, describing the variables, functional form, and estimation strategy. We then discuss the results, emphasizing the main findings, their economic relevance, and the contribution of each factor to the observed outcomes.

## 3.1 Specification

To estimate the probability that a firm exits the organic sector, we employ a panel logit model and focus on the marginal effects of explanatory variables to facilitate interpretation of their influence on exit likelihood. Let $\text{Exit}_{it}$ be a binary variable equal to 1 if firm $i$ loses its certification for organic production in period $t$, and 0 otherwise. The probability of exit is modeled as:

$$\mathbb{P}(\text{Exit}_{it} = 1 | \log y_{it}, (\log y_{it})^2, z_i, p_i, r_i) = G(\mathbf{X}_{it}) = \frac{\exp(\mathbf{X}_{it})}{1 + \exp(\mathbf{X}_{it})}, \ \forall i = 1, \dots, N_t, \text{ and } \forall t, \tag{3.1}$$

where:

$$\mathbf{X}_{it} = \beta_1 \log y_{it} + \beta_2 (\log y_{it})^2 + \zeta z_i + \rho p_i + \alpha r_i + \delta_t,$$

$N_t$ denotes the number of firms in our sample for each year, and $G(\cdot)$ is the logistic cumulative distribution function. The variable $y_{it}$ represents the age of firm $i$ at time $t$, measured in months. For firms that exited the organic sector, $y_{it}$ is computed as the difference between the exit date $t$ and the certification entry date. For firms that remained certified, age is calculated as the difference between year $t$ and the entry date. This duration variable helps account for differences in exposure time and mitigates the issue of survival bias, since firms that have remained longer in the sector may be systematically different from those that exit early. We include a quadratic term for firm age to capture the nonlinear pattern observed in the exit density: exits are concentrated among young firms and decline with age, with a slower accumulation for older firms (see Figure 7b).

The second explanatory variable, $z_i$, captures the certification body responsible for certifying firm $i$, allowing us to control for institutional heterogeneity. The dataset includes six certification bodies: *Québec-Vrai, Ecocert Canada, Pro-Cert Organic Systems Ltd., Letis S.A., QAI Inc.,* and *TransCanada Organic Certification Services*.

The vector $p_i$ contains variables indicating the types of organic products certified by the firm. These include, for example, alcohol, maple, animal products, vegetal products, prepared products, reconditioned products, and wild harvest. $r_i$ identifies the region in which firm $i$ is located, and $\delta_t$ captures time fixed effects, reflecting year-specific shocks that are common to all firms. We include year fixed effects in all specifications to control for common shocks or macroeconomic changes that could influence exit rates in each year. This ensures that our estimates reflect within-year and cross-firm variation, net of time-specific influences in 2023 and 2024.

**Model Choice.** We estimate a panel logit random effects model to analyze the probability of firm exit from the organic sector. This approach is chosen over both the fixed effects logit and the fixed effects probit models because of how fixed effects are handled in nonlinear panel estimations. The fixed effects logit model uses a method called conditional maximum likelihood, which removes unobserved firm-specific effects by conditioning on the number of events (e.g., exits) observed. This technique helps avoid the "incidental parameters problem," a well-known source of bias in nonlinear panel models when the number of time periods is small. In comparison, the fixed effects probit model does not admit such a correction and may produce inconsistent estimates in short panels. As noted by Greene (2004), this bias can be particularly problematic in datasets with few time periods, which is typical of our research.

However, the fixed effects logit model has a key limitation: it drops all time-invariant variables, such as region, product category, and certification type. Since many of our explanatory variables do not vary across time within firms, using fixed effects would prevent us from estimating their impact. To retain and interpret the effects of both time-varying and time-invariant covariates, we adopt a random effects specification. This model assumes that unobserved firm-level heterogeneity is uncorrelated with the observed regressors—a stronger assumption, but one that allows us to analyze structural factors that are central to our research question.

Given the short time span of our panel and our aim to assess how firm characteristics and certification types influence exit patterns, the random effects logit model provides a balanced and interpretable approach, while controlling for time-specific effects.

**Log-Odds and Marginal Effects.** To derive the model, we express the probability in terms of the log-odds, which provides a linear structure for estimation:

$$\log\left(\frac{\mathbb{P}(\text{Exit}_{it}=1)}{1-\mathbb{P}(\text{Exit}_{it}=1)}\right) = \beta_1 \log y_{it} + \beta_2 (\log y_{it})^2 + \zeta z_i + \rho p_i + \alpha r_i + \delta_t + \varepsilon_{it}. \tag{3.2}$$

While the coefficients $(\beta_1, \beta_2, \zeta, \rho, \alpha)$ represent changes in the log-odds of exit for a one-unit increase in the corresponding variable, our analysis focuses on the marginal effects, which quantify the change in the probability of exit, $\mathbb{P}(\text{Exit}_{it} = 1)$, for a one-unit change in an explanatory variable, holding all else constant. For the log-transformed age variable, the marginal effect is:

$$\frac{\partial \mathbb{P}(\text{Exit}_{it} = 1)}{\partial \log y_{it}} = G(\mathbf{X}_{it})\big(1 - G(\mathbf{X}_{it})\big)\big(\beta_1 + 2\beta_2 \log y_{it}\big). \tag{3.3}$$

The turning point at which the marginal effect changes sign satisfies:

$$\log y^* = -\frac{\beta_1}{2\beta_2}, \quad y^* = \exp\Big(-\frac{\beta_1}{2\beta_2}\Big). \tag{3.4}$$

After estimating the model for the full sample and computing $y^*$, we re-estimate separate models for younger firms ($y < y^*$) and older firms ($y \geq y^*$), excluding the squared term in each subgroup specification. This approach allows us to assess whether the linear relationship within each group aligns with the pattern predicted by the quadratic model.

When $\beta_1 > 0$ and $\beta_2 < 0$, the marginal effect of age on exit probability is positive for younger firms and negative for older firms. This implies that, initially, as firms age, their likelihood of exiting the organic sector increases. However, beyond the threshold $y^*$, additional age reduces the probability of exit. Economically, this pattern suggests that younger firms face higher exit risk due to limited experience and market integration, while older firms benefit from accumulated knowledge and established relationships, which enhance their survival prospects.

The model parameters are estimated using maximum likelihood. The log-likelihood function is:

$$\mathcal{L}(\beta_1, \beta_2, \zeta, \rho, \alpha) = \sum_{i,t} \left\{ \text{Exit}_{it} \cdot \log G(\mathbf{X}_{it}) + (1 - \text{Exit}_{it}) \cdot \log(1 - G(\mathbf{X}_{it})) \right\}, \tag{3.5}$$

where $\mathbf{X}_{it} = \beta_1 \log y_{it} + \beta_2 (\log y_{it})^2 + \zeta z_i + \rho p_i + \alpha r_i + \delta_t$. The estimated coefficients are used to compute marginal effects, which directly inform the results by quantifying the impact of each variable on the probability of exiting the organic sector.

## 3.2 Results

We estimate Equation (3.5) using a random-effects panel logit model with year fixed effects. Column (1) in Table 1 presents the average marginal effects for the full sample, with columns (2) reporting the corresponding standard errors. In the baseline specification (column 1), farmers' age enters through both $\log(age)$ and its squared term. The estimated positive coefficient on $\log(age)$, coupled with the negative coefficient on $\log^2(age)$, reveals a concave relationship between age and the likelihood of exit: the probability of exiting initially increases with age but eventually begins to decline. Based on the estimated parameters, the turning point occurs at roughly twelve months, after which additional tenure reduces the likelihood of exit.

**Table 1:** Marginal Effects on the Probability of Exit

| | Full Sample | | <12 months | | >12 months | |
|---|---|---|---|---|---|---|
| | Coef. | SE | Coef. | SE | Coef. | SE |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Firm Age** | | | | | | |
| log($age$) | 0.045** | (0.019) | 0.452*** | (0.159) | -0.034*** | (0.004) |
| $\log^2(age)$ | -0.009*** | (0.003) | - | - | - | - |
| **Certifier** | | | | | | |
| Quebec-Vrai | 0.037*** | (0.011) | -0.020 | (0.032) | 0.043*** | (0.012) |
| Pro-Cert | 0.0143 | (0.030) | | | 0.043 | (0.034) |
| Letis S.A. | | | | | | |
| QAI Inc | | | | | | |
| TransCanada Organic | | | | | | |
| *Ref: Ecocert Canada* | | | | | | |
| **Certified Product** | | | | | | |
| Alcohol | -0.019 | (0.025) | | | -0.013 | (0.026) |
| Maple | -0.095*** | (0.015) | -0.210** | (0.083) | -0.10*** | (0.015) |
| Livestock | -0.035** | (0.015) | | | -0.035** | (0.015) |
| Preparation | -0.036*** | (0.013) | -0.149* | (0.078) | -0.040*** | (0.013) |
| Plant | -0.018 | (0.013) | 0.018 | (0.026) | -0.025* | (0.013) |
| Packaging | -0.030** | (0.016) | -0.044 | (0.053) | -0.036** | (0.015) |
| Wild Harvest | 0.065* | (0.035) | -0.016 | (0.345) | 0.064** | (0.027) |
| **Region** | | | | | | |
| Estrie | -0.004 | (0.014) | -0.007 | (0.043) | -0.007 | (0.016) |
| Lanaudière | -0.045*** | (0.016) | -0.022 | (0.064) | -0.050*** | (0.018) |
| Outaouais | -0.000 | (0.023) | -0.098* | (0.051) | -0.000 | (0.025) |
| Montreal | -0.014 | (0.019) | 0.0314 | (0.103) | -0.0236 | (0.020) |
| Montérégie | -0.028** | (0.014) | -0.042 | (0.048) | -0.028* | (0.015) |
| Chaudière-Appalaches | -0.02 | (0.014) | 0.029 | (0.044) | -0.030* | (0.016) |
| Capitale-Nationale | -0.021 | (0.019) | -0.068 | (0.058) | -0.023 | (0.020) |
| Saguenay–Lac-Saint-Jean | -0.009 | (0.016) | -0.075 | (0.054) | -0.009 | (0.017) |
| Centre-du-Québec | -0.021 | (0.015) | -0.022 | (0.047) | -0.028 | (0.017) |
| Gaspésie–Îles-de-la-Madeleine | 0.032 | (0.037) | | | 0.042 | (0.041) |
| Laurentides | -0.000 | (0.018) | -0.083 | (0.051) | -0.000 | (0.019) |
| Abitibi-Témiscamingue | 0.004 | (0.029) | | | 0.011 | (0.032) |
| Mauricie | 0.013 | (0.023) | 0.132 | (0.188) | 0.010 | (0.025) |
| Côte-Nord | 0.231** | (0.097) | | | 0.113 | (0.082) |
| Nord-du-Québec | | | | | | |
| Laval | -0.007 | (0.036) | -0.087 | (0.054) | 0.006 | (0.038) |
| *Ref: Bas-Saint-Laurent* | | | | | | |
| **Year** | | | | | | |
| 2024 | 0.005 | (0.005) | -0.045* | (0.027) | 0.006 | (0.006) |
| Number of obs. | 7219 | | 483 | | 6722 | |

*Notes:* This table reports the marginal effects from the estimation of Equation (3.1). Standard errors are shown in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The corresponding panel logit estimation results are provided in Table A.2 in Appendix A. The estimates of some variables do not appear in the full-sample specification due to collinearity with other controls. After splitting the sample by age, additional variables are omitted because they either remain collinear or exhibit insufficient variation within the restricted subsamples, making their coefficients non-identifiable.

This estimated inflection motivates estimating the model separately for firms younger than twelve months and for those twelve months or older. If the quadratic form captures a genuine shift in exit behavior—as suggested by the density distribution in Figure 7—then age should be positively associated with exit among younger firms but negatively associated with exit among more established ones. Columns (3) and (5) of Table 1 implement this split and allow us to verify this interpretation directly.

The results align with this expectation. Among newly certified enterprises, increases in age raise the likelihood of exit, pointing to heightened vulnerability during the first months of organic production. For firms beyond the twelve-month threshold, the relationship reverses: additional tenure is associated with a lower likelihood of exit, consistent with growing experience, better adaptation, and improved capacity to maintain certification.

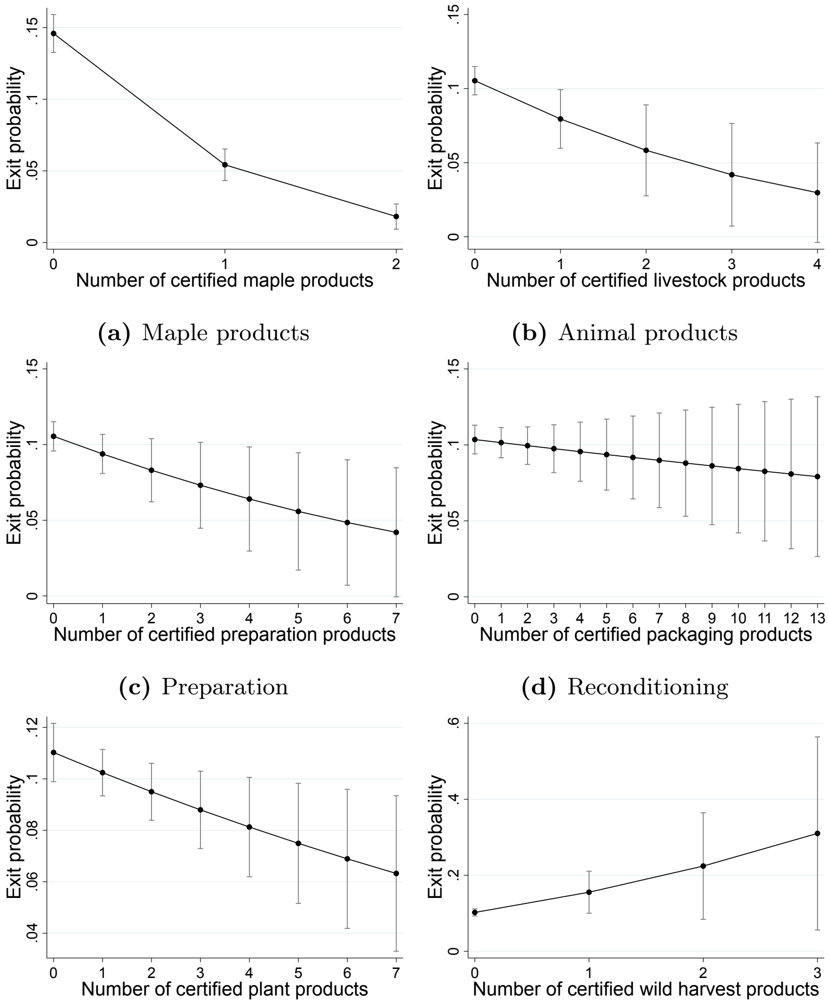
The choice of certifying body also significantly correlates with firm survival. Firms certified by Québec-Vrai have higher exit rates than those certified by Ecocert Canada, particularly for exits occurring after the first year. This may reflect differences in the level of support provided, the market recognition of certifiers, or the types of producers they attract. Certifiers influence not only the credibility of the organic label presented to consumers but also access to markets.

Certified product type is another strong predictor of exit. Firms producing maple products are consistently less likely to exit across all specifications. In contrast, those engaged in wild harvesting face significantly higher risks of exit, particularly after the first year. Meanwhile, enterprises certified for livestock, plant-based, packaging, or preparation products tend to show lower exit probabilities. These findings suggest that the type of production can contribute to enterprise resilience, whereas wild harvesting may involve greater regulatory, ecological, or market-related challenges that increase the likelihood of exit.

Finally, regional differences are also evident. Firms located in Lanaudière and Montérégie demonstrate lower exit rates compared to those in Bas-Saint-Laurent. In contrast, exits are more frequent in Côte-Nord. These findings may point to the role of localized support networks, market access, or production conditions in shaping certification outcomes.

We next re-estimate the model, focusing on the number of product certifications held by each firm within a given product category. This approach allows us to test whether diversification—beyond simply the type of product—affects the likelihood of exit on a particular product. Marginal effects were computed from the re-estimated model (full regression results are reported in Table A.3 in Appendix A). Figure 8 plots these marginal effects across product categories, showing how the probability of exit varies with the number of certified products. The figure reveals substantial heterogeneity: in most categories—particularly maple, livestock, plant, and preparation—the likelihood of exit declines as firms hold more certifications. This pattern indicates that greater diversification within a product category may enhance resilience, either by spreading risk or by generating economies of scope.

By contrast, wild harvest products (which represent 1% of total certifications) exhibit an opposite pattern: the probability of exit increases with the number of certified products. This finding departs from the stabilizing effect of diversification observed in categories such as organic wheat, dairy, or vegetables, and suggests that, in the case of wild-harvested goods, each additional certification may in fact amplify operational risks. This heightened vulnerability likely




**(a)** Maple products **(b)** Animal products

**(c)** Preparation **(d)** Reconditioning

**(e)** Plant **(f)** Wild harvest

**Figure 8:** Predicted probabilities of exit by number of certified products

*Notes:* This figure shows the effect of the number of certified products on the probability of firm exit, disaggregated by product category.

stems from the unique challenges associated with managing multiple uncontrolled harvest sites, each exposed to distinct environmental, regulatory, and logistical uncertainties. For instance, a firm certified for wild ginseng in one forested location might maintain compliance under relatively stable conditions, but expanding into mushrooms or berries could introduce new sources of non-compliance—such as pesticide drift from nearby farms or the ecological consequences of overharvesting.

Given that plant-related certifications account for nearly half of all organic certifications in Quebec, we further disaggregate the plant category to examine heterogeneity in exit behavior across crop types. This exercise allows us to identify which subcategories are most strongly associated with sectoral attrition, beyond the baseline comparison of plants versus other product categories. To this end, we estimate the model twice: first using only plant-related certifications, and then excluding maple products to isolate the effect of other crops.

Table A.5 in Appendix A summarizes the results. Cereals and oilseeds emerge as the most resilient segments, consistently exhibiting large and statistically significant negative coefficients across specifications. This pattern suggests that staple crops provide organic producers with a relatively stable economic foundation, likely reflecting stronger market integration and scale economies. In contrast, cultivated mushrooms display a markedly higher probability of exit, particularly when maple producers are excluded. This elevated risk may stem from the perishability, labor intensity, and market volatility inherent to mushroom production. Similarly, forage crops are associated with greater exit likelihood, underscoring the profitability challenges faced by organic livestock feed producers. In the next section, we construct a partial equilibrium model of transition in which firms can move from organic to conventional agriculture and are subject to uncertainty.

# 4 Theoretical Framework

This section develops a simple yet comprehensive framework to formalize farmers' decisions regarding the adoption and persistence of organic farming. The model captures the key economic and environmental mechanisms suggested by the descriptive evidence while remaining tractable enough for policy calibration. It highlights the role of heterogeneity in time preferences, differences in price incentives across production regimes, exposure to environmental risks, and the influence of certification and reversion costs. Together, these elements generate realistic dynamics of entry and survival in organic farming that can be compared with observed data and simulated under alternative policy scenarios.

## 4.1 Heterogeneous Farmers and Production Regimes

Farmers differ in their intertemporal preferences, which determine their willingness to incur short-term transition costs in exchange for long-term environmental and economic benefits. Each farmer is indexed by a discount factor $\beta^{\theta}$, with $\theta \in \{\underline{\theta}, \overline{\theta}\}$, where $\underline{\theta}$ represents an *impatient* type and $\overline{\theta}$ a *patient* type, such that $\beta^{\underline{\theta}} < \beta^{\overline{\theta}}$. While both types face the same expected profit opportunities, patient farmers place greater weight on future income streams and are therefore more willing to stay in organic practices that may generate delayed but higher returns.

Production can occur under two regimes: conventional farming, $C$, and organic farming, $O$. These regimes differ in their input composition, exposure to environmental shocks, and the nature of market and policy incentives. Conventional farming relies on chemical inputs such as pesticides to stabilize yields but is subject to regulatory taxation. In contrast, organic farming abstains from synthetic inputs, receives price premiums and per-unit subsidies, but remains more exposed to biological risks such as pest infestations.

The profit function in each regime captures output revenues net of input costs, including the effects of policy parameters and stochastic shocks. In the conventional regime, production depends on the use of conventional inputs $z^c$ and pesticide applications $x$. Per-period profits are defined as:

$$\pi_c(z^c, x) = p_c \cdot f(z^c, x) - \mu_z \cdot z^c - (1+\tau)p_x \cdot x, \tag{4.1}$$

where $f(\cdot)$ denotes the production function, $p_c$ is the output price, $\mu_z$ the unit cost of conventional inputs, $p_x$ the pesticide price, and $\tau$ a pesticide tax rate. The use of pesticides mitigates pest-related losses.

In the organic regime, farmers face higher biological risk but benefit from policy support and market premiums. The per-period profit is:

$$\pi_o(z^o, \sigma^t) = (p_o + s) \cdot \sigma^t f(z^o) - \mu_o \cdot z^o, \tag{4.2}$$

where $p_o > p_c$ represents the organic price premium, $s$ is a per-unit subsidy, $z^o$ denotes organic-specific inputs, and $\mu_o$ is their unit cost. The stochastic term $\sigma^t \in \{\sigma_1, \ldots, \sigma_N\}$ captures pest idiosyncratic shocks in the organic sector during period $t$, evolving according to a Markov process with transition probabilities:

$$\Omega_{ij} = \text{Prob}(\sigma^{t+1} = \sigma_j \mid \sigma^t = \sigma_i), \quad i, j \in \{1, 2, \ldots, N\}. \tag{4.3}$$

The absence of chemical protection makes the organic regime more sensitive to these biological disturbances. Each state $\sigma_i$ represents a level of pest pressure affecting yields, and the dynamics of the process are governed by the transition matrix $\Omega$. Including these shocks is essential to capture realistic yield variability and the risk of exit in organic farming, as empirical studies document substantial yield losses from pest pressure and other environmental uncertainties (e.g., de Ponti et al. 2012, Ponisio et al. 2015, Kular & Kumar 2017). Modeling stochastic disturbances allows the theoretical framework to reflect both the short-term volatility and long-term risk management decisions that characterize organic production. The probability that the pest environment is in state $\sigma_i$ after $t$ periods of organic farming is denoted by $\Phi_{i,t}$, which evolves as:

$$\Phi_{j,t} = \sum_{i=1}^{N} \Omega_{ij} \Phi_{i,t-1}, \tag{4.4}$$

starting from a uniform initial distribution $\Phi_{i,0} = 1/N$ for all $i$. This assumption implies that upon entry into organic farming, pest conditions are initially unknown and equally likely across all possible states.

## 4.2 Dynamic Optimization

Farmers make dynamic decisions under uncertainty, weighing short-term profits against long-term benefits and risks. Their problem can be expressed in terms of value functions that account for potential regime switching between conventional and organic farming. The intertemporal discount factor, $\beta^\theta \in (0, 1)$, reflects each farmer's degree of patience, with higher values of $\beta^\theta$ corresponding to a greater valuation of future payoffs.

**Conventional Regime.** In the conventional regime, a farmer chooses input levels and decides whether to remain conventional or switch to organic production. All policy and market variables are collected in the exogenous state vector $\Psi = (\tau, s, p_c, p_o)$, which includes the pesticide tax, organic subsidy, and the conventional and organic output prices. The value function for a conventional farmer of type $\theta$ satisfies the Bellman equation:

$$V_C^\theta(\Psi) = \max_{z^c, x} \Big\{ \pi_c(z^c, x) + \beta^\theta V_C^\theta(\Psi') \Big\}, \tag{4.5}$$

where $\Psi'$ represents next-period policy and market conditions, and $\sigma_0$ denotes the initial pest state upon conversion to organic farming. The first term in the maximization captures optimal input use under conventional farming, while the second term represents the forward-looking decision to either continue conventionally or initiate the transition to organic production.

**Organic Regime.** In the organic regime, a farmer of type $\theta$ who has spent $t$ periods in organic production chooses organic input levels and decides whether to remain organic or revert to conventional farming. The corresponding value function is:

$$V_O^\theta(\Psi, \sigma^t) = \max_{z^o} \Big\{ \pi_o(z^o, \sigma^t) + \beta^\theta \mathbb{E}_{\sigma^t} V_O^\theta(\Psi', \sigma^{t+1}) \Big\}, \tag{4.6}$$

where $\sigma^t$ denotes the pest shock intensity after $t$ periods in the organic sector. The first term corresponds to current-period profits, and the second captures the dynamic trade-off between reverting to conventional farming and remaining organic while facing stochastic pest conditions.

As current profit, $\pi_o(z^o, \sigma^t)$, decreases with the pest shock level, the value of remaining in organic production, $V_O^\theta(\Psi, \sigma^t)$, also declines with the pest level $\sigma^t$. Yet, a higher $\beta^\theta$ implies a higher $V_O^\theta(\Psi, \sigma^t)$. This is because $\beta^\theta$ represents the discount factor, capturing the farmer's patience or long-term orientation. When $\beta^\theta$ is large, future profits, $V_O^\theta(\Psi', \sigma^{t+1})$, weigh more heavily in the decision-making process, mitigating the negative impact of current pest shocks. Consequently, even if short-term returns are low, a patient farmer anticipates recovery and future gains, making the option to remain in organic production valuable. In contrast, a lower $\beta^\theta$ amplifies the effect of current losses, which may accelerate the switch away from organic practices.

**Exit Decision.** A farmer exits the organic regime when the expected value of returning to conventional farming exceeds the continuation value of remaining organic. This behavioral rule is modeled as a smooth logit probability function:

$$P_{t,\sigma_j}^\theta = \frac{1}{1 + \exp\big[-\gamma\big(V_C^\theta(\Psi) - V_O^\theta(\Psi, \sigma_j)\big)\big]}, \tag{4.7}$$

where $\gamma > 0$ governs the sensitivity of exit behavior to differences in continuation values. A higher $\gamma$ implies that farmers respond more sharply to profitability differentials across regimes.

The probability that a farmer of type $\theta$ exits the organic sector after $t$ periods, across all pest shock states, is given by:

$$P_t^\theta = \sum_{j=1}^{N} \Phi_{j,t} \, P_{t,\sigma_j}^\theta, \tag{4.8}$$

Equation (4.8) defines the aggregate exit probability for a producer of type $\theta$ as the weighted sum of state-contingent exit probabilities, where each weight $\Phi_{j,t}$ denotes the likelihood that the pest process is in state $\sigma_j$ at time $t$. The distribution $\{\Phi_{j,t}\}_{j=1}^N$ evolves according to the Markov transition law in Equation (4.4), reflecting both the persistence and the stochastic transitions of pest conditions over time. Accordingly, any perturbation that shifts probability mass toward higher pest states—either through an unfavorable realization or a change in the transition matrix $\Omega$—translates into a higher aggregate exit probability.

As the continuation value of remaining in organic production, $V_O^\theta(\Psi, \sigma^t)$, falls with $\sigma^t$, which raises the conditional exit probability $P_{t,\sigma_j}^\theta$ via Equation (4.7). Thus, pest shocks influence exits through two reinforcing channels: they increase the probability of being in unfavorable pest states, $\Phi_{j,t}$, and raise the propensity to exit within those states, $P_{t,\sigma_j}^\theta$. Both effects push upward the overall likelihood of exit, $P_t^\theta$.

The magnitude of this response depends on the producer's type $\theta$. More patient farmers, characterized by a higher discount factor $\beta^\theta$, attach greater weight to future profits, $V_O^\theta(\Psi', \sigma^{t+1})$, and are therefore less responsive to temporary pest shocks. For them, the decline in $V_O^\theta(\Psi, \sigma^t)$ is partly offset by the expected recovery of yields in future periods, which sustains the incentive to remain in organic production. In contrast, producers with lower $\beta^\theta$ are more short-sighted; the current loss in profitability dominates their decision, leading to a sharper increase in exit probability when pest intensity rises. Persistent pest regimes—where the transition matrix $\Omega$ allocates substantial weight to remaining in high-$\sigma$ states—further amplify these differences by prolonging exposure to adverse conditions, thus magnifying the cumulative effect of pest shocks on exit dynamics across heterogeneous producers.

**Survival Dynamics.** Let $S_t^\theta$ denote the share of farmers of type $\theta$ that remain in the organic sector after $t$ periods. The evolution of survival follows the recursive process:

$$S_t^\theta = S_{t-1}^\theta (1 - P_{t-1}^\theta), \tag{4.9}$$

where the initial shares $S_0^\theta$ represent the population composition at certification, and are normalized such that $\sum_{\theta \in \{\underline{\theta}, \bar{\theta}\}} S_0^\theta = 1$. Aggregate exit flows from the organic sector in period $t$ are then given by:

$$E_t = \sum_{\theta \in \{\underline{\theta}, \bar{\theta}\}} S_t^\theta P_t^\theta, \tag{4.10}$$

which, using Equation (4.8), can be rewritten as:

$$E_t = \sum_{\theta \in \{\underline{\theta}, \bar{\theta}\}} \sum_{j=1}^{N} S_t^\theta \Phi_{j,t} P_{t,\sigma_j}^\theta. \tag{4.11}$$

Finally, the conditional aggregate probability of exit from the organic sector after $t$ periods is defined as the ratio between total exit flows and the number of farmers at risk at the beginning of period $t$:

$$P_t = \frac{E_t}{S_t}, \tag{4.12}$$

where $S_t = \sum_{\theta \in \{\underline{\theta}, \bar{\theta}\}} S_t^\theta$ denotes the total number of organic farmers remaining in the sector at the beginning of period $t$.

This framework implies that all uncertainty in farmers' dynamic choices arises from the stochastic evolution of pest conditions. Consequently, the persistence and survival of organic farms depend jointly on the trajectory of biological risks, the heterogeneity in farmers' time preferences, and the configuration of exogenous parameters such as prices, taxes, and subsidies.

The next section applies the model empirically, detailing the calibration of key parameters, the estimation of exit dynamics, and the policy simulations that assess how alternative instruments affect the long-run viability of organic farming.

# 5 Quantitative Analysis

The quantitative analysis builds on the theoretical framework to empirically assess the exit dynamics of organic producers. It relies on two complementary data sources and proceeds in three steps: calibration of production and behavioral parameters, evaluation of model fit, and examination of policy interventions under alternative scenarios.

## 5.1 Data and Calibration

The calibration aims to identify the structural parameters of the model describing the exit dynamics of organic and conventional producers. It relies on two complementary data sources: exit information from the *Portail Bio Québec* and sectoral data from the *Centre de Référence en Agriculture et Agroalimentaire du Québec* (CRAAQ).

**Production Parameters.** The CRAAQ dataset covers the 2019–2024 period and provides average yields, selling prices, and production costs for three major crops in Quebec—corn, soybean, and barley—which together account for approximately 77% of total field crop acreage between 2019 and 2022. Using these data, we compute average per-hectare outputs, input costs, product prices for both conventional and organic regimes, as well as pesticide expenditures per hectare reported by CRAAQ. Table 2 summarizes these averages over the period 2019-2024.

**Table 2:** Revenue and Expenses by Crop Management in Quebec (2019–2024)

| | Corn | | Soybean | | Barley | |
|---|---|---|---|---|---|---|
| | Org. | Conv. | Org. | Conv. | Org. | Conv. |
| Prices ($) | 490 | 277 | 1151 | 564 | 458 | 328 |
| Yields (per ha) | 9.1 | 10 | 2.9 | 3.09 | 2.69 | 4 |
| Total costs excluding pesticides ($/ha) | 1848 | 1857 | 812 | 869 | 997 | 1219 |
| Pesticide expenditures ($/ha) | – | 90 | – | 95 | – | 57 |

*Notes:* This table reports for each sector —organic and conventional— average prices, yields, and production costs for Quebec field crops between 2019 and 2024. The total costs exclude pesticide expenditures, which are shown separately. Pesticide expenditures refer to synthetic products, absent in the organic regime.

**Behavioral Parameters.** Given a policy setting $(s, \tau)$, the conventional profit $\pi_c$ and the organic profit conditional on the shock $\sigma^t$ are evaluated according to equation (4.2). The present value of the conventional regime is expressed as:

$$V_C^\theta(\Psi) = \frac{1}{1-\beta^\theta}\, \pi_c(z^c, x), \tag{5.1}$$

where $\beta^\theta$ denotes the discount factor associated with farmer type $\theta$. In the organic regime, profit depends on the stochastic shock $\sigma^t$, which evolves according to a Markov process characterized by the transition matrix $\Omega$. The organic value function aggregates expected future profits across all possible states, weighted by their transition probabilities and are given by:

$$\begin{pmatrix} V_O^\theta(\Psi, \sigma_1) \\ V_O^\theta(\Psi, \sigma_2) \\ \vdots \\ V_O^\theta(\Psi, \sigma_N) \end{pmatrix} = (\mathbb{I}_N - \beta^\theta \Omega)^{-1} \begin{pmatrix} \pi_o(z^o, \sigma_1) \\ \pi_o(z^o, \sigma_2) \\ \vdots \\ \pi_o(z^o, \sigma_N) \end{pmatrix}, \tag{5.2}$$

where $\mathbb{I}_N$ is the $N$-dimensional identity matrix. These two value functions are then used to derive exit probabilities, exit flows, and aggregate exit rates following Equations (4.7), (4.10), and (4.12).

The *Portail Bio Québec* dataset provides, for each firm, the year of certification and the year of exit from the organic sector. This information allows us to compute the firm's duration or "age" $t$ in the sector and to group producers by cohort.[5] For each age $t$, we observe the number of exits $\hat{E}_t$ and the exit probability $\hat{P}_t$, defined as the ratio of exits to the total number of firms active at that age. Observed durations extend up to 33 years, and the series $\{\hat{E}_t, \hat{P}_t\}$ serve as empirical calibration targets.

Formally, the calibration estimates the parameter vector $\chi = \{\beta^{\underline{\theta}}, \beta^{\overline{\theta}}, \gamma, S_0^{\underline{\theta}}, \{\sigma_i\}_{i=1}^N, \Omega\}$, where $\beta^{\underline{\theta}}$ and $\beta^{\overline{\theta}}$ denote the discount factors of impatient and patient farmers, $\gamma$ is the behavioral sensitivity parameter, $S_0^{\underline{\theta}}$ the initial share of impatient farmers, $\sigma_i$ the productivity multipliers associated with the different pest-shock states, and $\Omega$ the Markov transition matrix characterizing the pest dynamics. The initial distribution of shocks $\Phi_{j,0}$ is assumed to be uniform across all possible states.

The shock process is approximated by a discrete $N$-state Markov chain $\{\sigma_1, \ldots, \sigma_N\}$ representing increasing levels of pest intensity[6]. The transition matrix $\Omega$ captures the persistence of the process, while the productivity differentials $\sigma_i$ quantify the impact of pest shocks on organic yields.

Pest shocks and behavioral parameters $\chi = \{\beta^{\underline{\theta}}, \beta^{\overline{\theta}}, \gamma, S_0^{\underline{\theta}}, \{\sigma_i\}_{i=1}^N, \Omega\}$ are determined by minimizing the distance between simulated and observed exits using the following objective

[5] A cohort refers to all firms sharing the same age. For instance, a firm certified in 2024 and exiting after one year is treated as equivalent to a firm certified in 2023 and exiting in 2024. Agents are thus homogeneous in their exit behavior; they differ only in the shocks affecting their productivity, their time spent in the sector, and their degree of patience.

[6] We consider an ad hoc of three levels of pest intensity, $N = 3$, and allow the model to calibrate their values.

function:

$$\min_{\chi} \sum_{t=1}^{T} \omega_t \left[ (P_t - \hat{P}_t)^2 + \lambda (E_t - \hat{E}_t)^2 \right], \tag{5.3}$$

where $\omega_t$ is a weighting factor proportional to the number of observations at each age $t$, and $\lambda$ controls the relative weight assigned to fitting exit probabilities versus exit flows.

The calibration proceeds by minimizing the discrepancy between simulated and observed exit dynamics. The optimization follows a Sequential Quadratic Programming routine in which, at each iteration, the parameter vector $\chi$ is updated to reduce the value of the objective function (5.3). After each update, the survival trajectories $S_t^{\theta}$ are recomputed according to Equation (4.9), and the corresponding series $E_t, P_t$ are regenerated. To avoid convergence toward local minima, the procedure is initiated from multiple starting values drawn over the admissible parameter space. The algorithm iterates over these sequences until the distance between simulated and observed exits, measured by the root-mean-square deviation, falls below 1%, ensuring numerical convergence of the estimated parameters. The following section discuss the results and the model fit for policy analysis.

## 5.2 Results and Model Fit

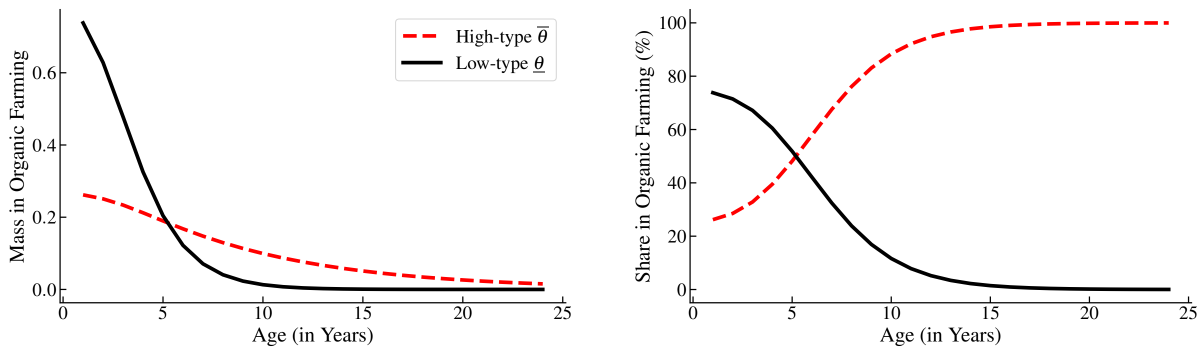
The calibrated parameters offer a structural interpretation of the observed exit dynamics in the organic farming sector. Temporal heterogeneity in producers' time preferences is captured by the difference between $\beta^{\underline{\theta}}$ and $\beta^{\overline{\theta}}$, where $\beta^{\overline{\theta}}$ denotes a more patient type less prone to early exit, and $\beta^{\underline{\theta}}$ reflects a present-biased type with a higher likelihood of transitioning out of organic production. The parameter $\gamma$ quantifies the sensitivity of exit decisions to expected profitability differentials between organic and conventional regimes, thereby linking economic incentives to behavioral responses. The transition matrix $\Omega$ and the pest shock coefficients $\sigma_i$ characterize the persistence and intensity of biophysical risks, which further shape producers' dynamic choices. Calibration results are summarized in Table 3.

**Table 3:** Calibrated Parameters

| Parameter | Description | Value |
|---|---|---|
| $\beta^{\underline{\theta}}$ | Discount factor (low-type $\underline{\theta}$) | 0.700 |
| $\beta^{\overline{\theta}}$ | Discount factor (high-type $\overline{\theta}$) | 0.949 |
| $\gamma$ | Sensitivity to value differences | 0.003 |
| $S_0^{\overline{\theta}}$ | Initial share of high type | 0.262 |
| $\sigma_1$ | Pest-shock state 1 | 1.000 |
| $\sigma_2$ | Pest-shock state 2 | 0.950 |
| $\sigma_3$ | Pest-shock state 3 | 0.600 |

*Notes:* This table reports the calibrated values of the model parameters, estimated by solving the minimization problem defined in Equation (5.3).

**Time Preferences and Producer Types.** The calibrated discount factors estimated are $\beta^{\underline{\theta}} = 0.700$ for the present-biased (low-type $\underline{\theta}$) producers and $\beta^{\overline{\theta}} = 0.949$ for the more patient




**(a)** Level **(b)** Proportion

**Figure 9:** Evolution of Estimated Farmer Types in Organic Farming Over Time

*Notes:* This figure illustrates the dynamics of patient (dashed red line) and impatient (solid black line) farmers' participation in organic farming. Panel (a) depicts their participation levels, measured by their respective masses in the organic sector, while Panel (b) shows the proportion of each farmer type within the organic sector over time.

(high-type $\overline{\theta}$) producers. These values lie within the empirically observed range of time preference parameters in agricultural economics—typically between 0.60 and 0.95—consistent with estimates reported by Leblanc et al. (2021) and related studies for Quebec. The calibration thus aligns well with observed behavioral heterogeneity among farmers regarding intertemporal trade-offs.

At the time of entry into the organic sector, the composition of producers reflects this behavioral distribution. The initial share of patient farmers is estimated at roughly one quarter of the total organic population, implying that nearly three-quarters of early adopters are impatient producers. This predominance mirrors the broader agricultural landscape, where conventional farming continues to represent more than 90% of all agricultural enterprises in Quebec (see Figure 2). Given their numerical dominance in the overall population, impatient producers are statistically more likely to enter organic farming, even though their short-term orientation limits their capacity to sustain participation over time.

The dynamic adjustment in the composition of the organic sector is depicted in Figure 9. Panel (a) presents the evolution of the number of organic farmers by type, while Panel (b) illustrates the corresponding shares over time. At entry, impatient producers dominate the organic population; however, their attrition rate is considerably higher in the early years. Patient producers, by contrast, display substantially greater persistence, gradually becoming the majority among long-term participants. This dynamic supports the hypothesis that organic farmers tend to be more patient than their conventional counterparts—a pattern consistent with the findings of Piovesan (2019) for soybean and corn producers in Quebec.

Taken together, these results offer a dynamic interpretation of the observed coexistence of high initial exit rates and strong persistence among surviving organic farms. The sector's early composition, driven by the prevalence of impatient entrants, gives rise to substantial turnover. Over time, selection operates through differential survival, leading to an organic farming population increasingly dominated by patient producers whose long-term outlook aligns with the sustained commitments that organic production entails.

The estimated behavioral sensitivity parameter $\gamma$ indicates a limited responsiveness of exit decisions to short-term differences in expected values between the two regimes. This implies that producers do not adjust immediately to profitability differentials but rather respond to long-term incentives and yield uncertainty. Such inertia reflects the structural nature of the decision to exit organic farming, where sunk costs, certification delays, and risk exposure may play more important role.

**Yield Shocks and Pest Dynamics.** Yield shocks in the organic regime capture the heterogeneity and volatility associated with pest pressure. The calibrated states, $\sigma_i, i = 1, 2, ..., N$, represent yield variations of up to 40% between the most favorable and least favorable conditions, consistent with the variability reported by Sexton et al. (2007) and Piovesan (2019). The transition matrix $\Omega$ is estimated as follows:

$$\Omega = \begin{bmatrix} 0.442 & 0.510 & 0.047 \\ 0.000 & 0.429 & 0.571 \\ 0.005 & 0.000 & 0.995 \end{bmatrix}. \tag{5.4}$$

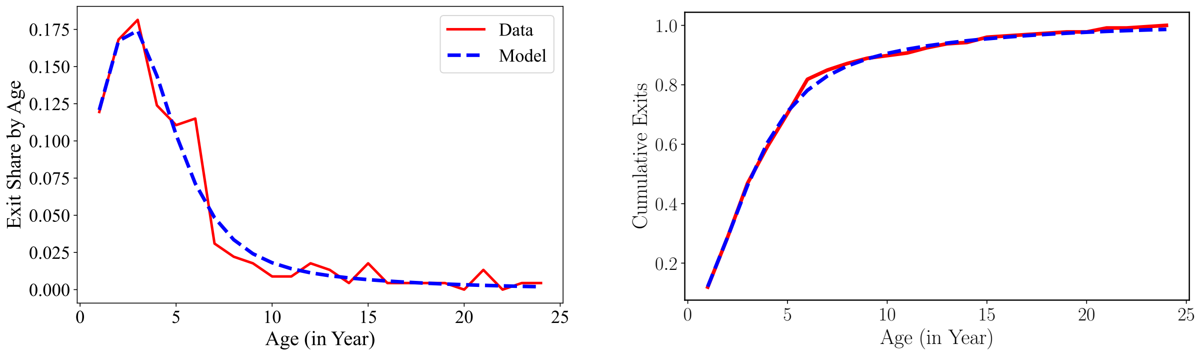
The transition matrix $\Omega$ encodes the recurrent yet non-permanent nature of pest pressures that shape farmers' dynamic choices under the organic regime. Its Markov structure parallels the productivity processes in Hopenhayn (1992), where persistence in idiosyncratic shocks governs firms' survival and exit. A similar mechanism operates here: farmers remain organic as long as biological conditions are manageable, but persistent pest shocks erode their productivity to the point where exit becomes the optimal response.

The estimates highlight this mechanism clearly. The low value of $\Omega_{13} = 0.047$ indicates that transitions from the most favorable state $\sigma_1$ to the most severe pest condition $\sigma_3$ are relatively rare. In contrast, the estimate $\Omega_{33} = 0.995$ shows that once a producer falls into the worst state—where output is reduced by 40% (i.e., $\sigma_3 = 0.6$)—escaping this condition is extremely unlikely in the absence of pesticide use. Such high persistence in biological stressors accumulates over time, gradually eroding the value of staying organic and ultimately pushing even high-type farmers toward exit.

**Model Fit.** We now turn to evaluating the model's ability to replicate the observed data. Figure 10a shows the distribution of exits by age. Overall, the calibrated model in dashed blue line perfectly replicates the observed trajectory in solid red line of exit share—the proportion of exits by each age group—validating its ability to capture the main exit dynamics in the organic sector. Figure 10b offers a comparison of the cumulative exit patterns generated by the model with those observed in the empirical data. To assess the robustness of the estimated parameters, we alternatively use the 2024 data for calibration. The estimates shown in Table A.6 (see Appendix A) are consistent with previous estimations.

## 5.3 Policy Analysis

Building on the calibrated model, we conduct a series of counterfactual simulations to evaluate the potential effects of alternative policy interventions on the dynamics of exit from organic farming. Specifically, we consider four scenarios: (i) a post-certification subsidy targeting newly




**(a)** Share of Exits by Age Group

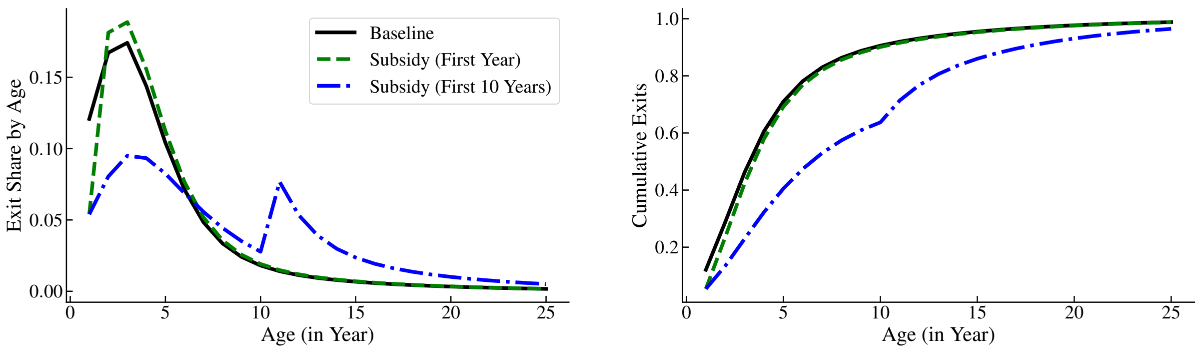
**(b)** Cumulative Exit Shares

**Figure 10:** Exit Share and Probability Dynamics: Model vs 2023 Data

*Notes:* This figure assesses the model's fit by comparing the calibrated distribution of exits over time with the data. The distribution of exits, Exit Shares, are computed as the ratio of total exits at each age to the initial number of entrants, $E_t/S_0$.

certified organic producers, (ii) a long-term transition subsidy providing financial support over multiple years, (iii) a pesticide tax aimed at discouraging conventional practices, and (iv) intensified pest shocks representing the absence of chemical treatments. These scenarios are chosen to reflect both existing and proposed instruments within Quebec's agricultural policy framework. The analysis examines how financial incentives, regulatory measures, and biophysical risks interact with producer heterogeneity to shape retention in the organic sector.

**Subsidy-Based Interventions.** We consider two post-certification support schemes: (i) a one-off subsidy of \$100 per hectare, paid in the first year following organic certification—an incentive structure consistent with the *Prime-Vert* program for cereals, oilseeds, and legumes; and (ii) a long-term transition subsidy of \$100 per hectare paid annually over the first ten years.




**(a)** Exit shares

**(b)** Cumulative exit shares

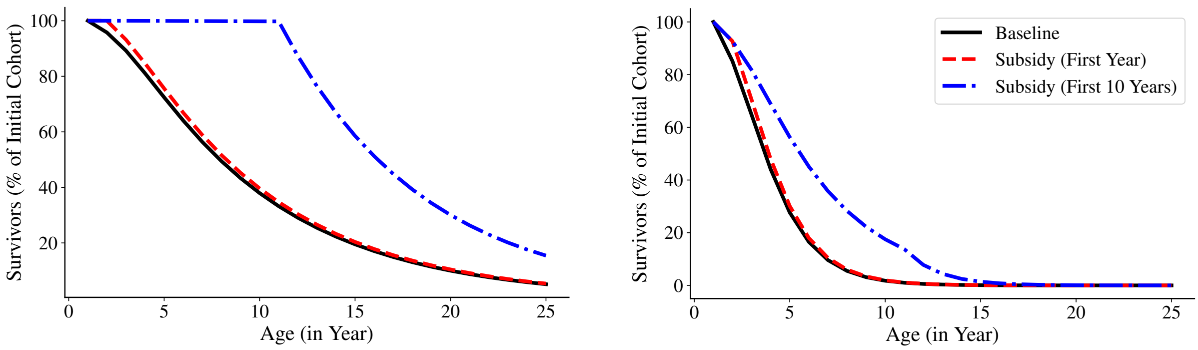
**Figure 11:** Organic Exit Dynamics Under Subsidy Policies

*Notes:* This figure shows the exit dynamics under subsidy policies. Panel (a) reports simulated annual exit shares across policy environments; Panel (b) shows the corresponding cumulative exits. Two policies are considered: (i) a first-year post-certification subsidy of \$100/ha; and (ii) a ten-year transition subsidy of \$100/ha per year.

Simulation results indicate that a one-year subsidy leads to a modest but temporary decline in exits. In the baseline scenario, 12.1% of total exits occur within the first year. Under the one-year subsidy, this share declines to 5.4%. The difference of 6.7 percentage points corresponds to roughly 55.4% of the new entrants who would otherwise exit during their first year. As shown in Figure 11, the effect is confined to the year of payment and dissipates rapidly once support is withdrawn.

Extending the subsidy to ten years generates larger and more persistent effects. By year 10, cumulative exits reach 64% under the ten-year subsidy, compared with 90.6% in the baseline scenario. This represents a 26.6% improvement in farmer retention after ten years. However, once payments end, exits rise sharply—most notably among patient producers—revealing that subsidies primarily ease short-run financial pressures and temporarily sustain expectations of future revenue gains rather than altering long-run fundamentals.

At inception, the organic sector comprises a mix of impatient and patient farmers, each exhibiting distinct survival dynamics over time (Figure 9). Impatient farmers display steep attrition, with survival rates declining rapidly after entry. By the end of 10 years, none of the initial cohort remains active. This pattern reflects their short-term orientation: while they enter the sector quickly, they also exit when immediate returns fail to materialize. Subsidies—whether limited to the first year or extended—do little to alter this trajectory. The marginal effect is negligible (see Figure 12b) because impatient farmers are unwilling to commit beyond the short term, even when liquidity constraints are temporarily eased.




**(a)** Patient Farmers $\overline{\theta}$ **(b)** Impatient Farmers $\underline{\theta}$

**Figure 12:** Survival Dynamics in the Presence of Subsidy Policies

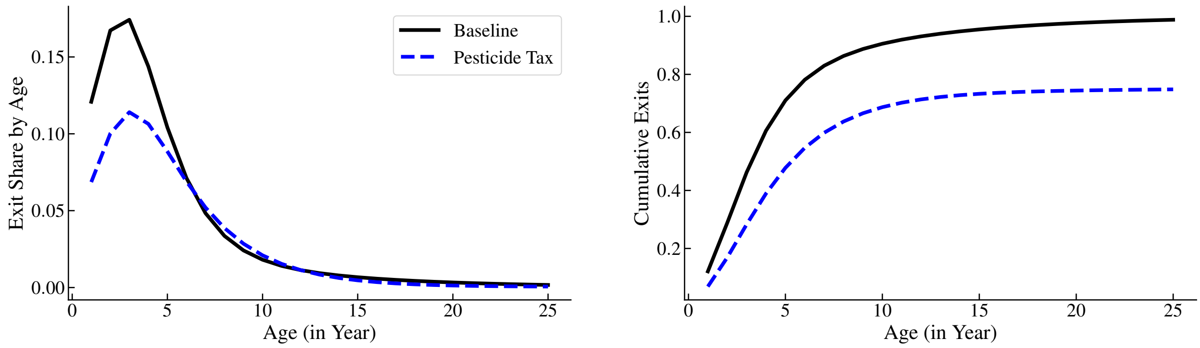
*Notes:* This figure depicts survival trajectories for impatient and patient farmers under alternative subsidy regimes. Panel (a) illustrates patient farmers, where extended subsidies (ten years) substantially improve retention compared to baseline and one-year support. Panel (b) shows impatient farmers, whose survival declines steeply regardless of policy, indicating limited responsiveness to subsidies.

Patient farmers, in contrast, exhibit slower attrition but represent a smaller share of the overall farmer population. Their decline is less abrupt than that of impatient farmers. Policy interventions significantly reshape these dynamics. A one-year subsidy provides only temporary relief, failing to prevent eventual exit. However, a ten-year subsidy markedly improves survival, sustaining a larger share of the cohort over time (see Figure 12a). Extended support bridges the gap between initial investment and delayed payoff, allowing patient farmers to realize the benefits of their long-term strategy.

These dynamics reveal strong heterogeneity in policy effectiveness. Impatient farmers exit quickly regardless of support, while patient farmers respond positively to sustained subsidies.

Uniform subsidy schemes are therefore inefficient. A differentiated approach—targeting extended assistance to patient farmers and limiting support for impatient farmers—would optimize resource allocation and enhance the stability of the organic sector. The result echoes Acs et al. (2009), who show that while annual subsidies of €148–441/ha can stimulate adoption depending on risk preferences, their influence remains conditional—once support ends, risk-averse or impatient producers may still exit.

**Tax-Based Interventions.** We now examine the pesticide tax scenario, which simulates an 80% increase in pesticide prices, consistent with the objectives of Quebec's *Sustainable Agriculture Plan* (SAP). This tax rate is based on the findings of Séguin & Thiam (2025), who show, using a CGE model calibrated to the Quebec economy, that such a level of taxation would achieve roughly a 12% reduction in pesticide use — the target set by the SAP.




**(a)** Exit Shares

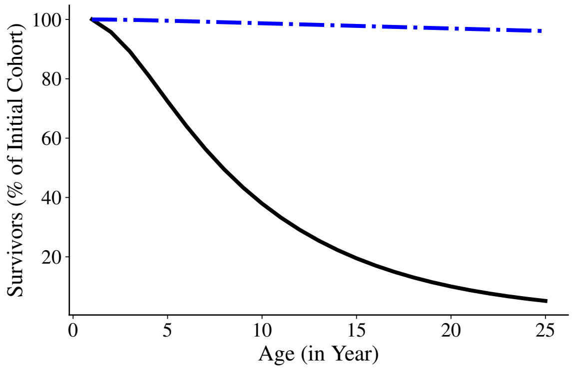
**(b)** Cumulative Exit Shares

**Figure 13:** Organic Exit Dynamics Under Pesticide Tax Policy

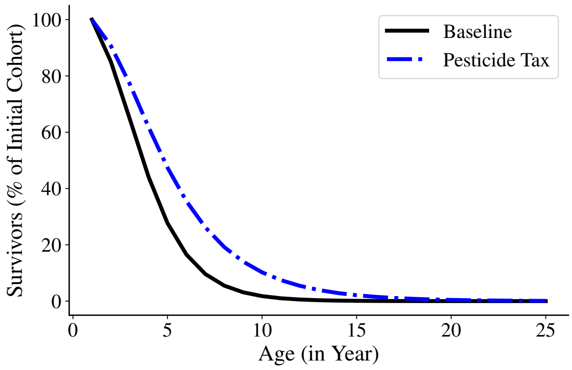
*Notes:* This figure illustrates the effects of an 80% pesticide tax, consistent with Quebec's *Sustainable Agriculture Plan* (SAP), which seeks to reduce pesticide use and promote the transition toward more sustainable production. Panel (a) displays the simulated annual exit shares of organic farmers under both the baseline and tax scenarios, while Panel (b) presents the corresponding cumulative exits over time.

Simulation results show that the tax primarily affects young organic farms—those operating for less than five years. In the baseline scenario, exits occurring during the first year account for about 12.1% of total exits, whereas under the tax this share declines to roughly 6.9%. This finding suggests that the tax mainly discourages short-term reversions to conventional farming, which are most frequent among impatient or newly established producers. By increasing the relative cost of pesticides, the tax reduces the incentive for early reversion and stabilizes participation during the initial years.

Around the fifth year, the difference between the two trajectories becomes negligible. Both the tax and baseline scenarios converge toward similar exit rates. This convergence reflects a compositional adjustment within the organic sector: by that time, most impatient producers have already exited the market. Indeed, the contrast is stark—after 15 years, survival among impatient farmers ($\underline{\theta}$) falls to about 2%, meaning that more than 98% have reverted to conventional farming. In contrast, patient farmers ($\overline{\theta}$) exhibit remarkable resilience: under the tax policy, their cumulative exit rate after 25 years remains below 5%. This outcome underscores the tax's effectiveness in securing long-term retention among patient producers, while its influence on impatient farmers is concentrated in the early years.




**(a)** Patient Farmers $\overline{\theta}$




**(b)** Impatient Farmers $\underline{\theta}$

**Figure 14:** Survival Dynamics in the Presence of Tax Policies

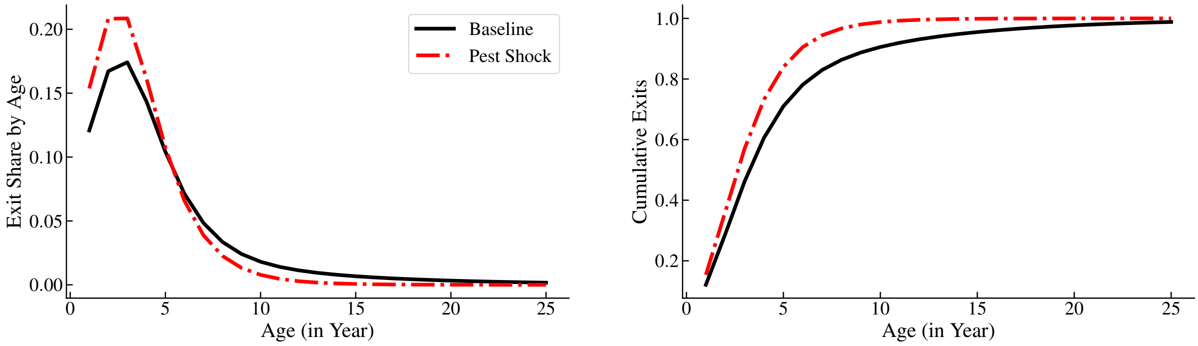
*Notes:* This figure compares the survival trajectories of impatient ($\underline{\theta}$) and patient ($\overline{\theta}$) producers under an 80% pesticide tax scenario.

Over a comparable ten-year horizon, cumulative exits under the pesticide tax reach 68.7% of the initial entrants, compared to 63.7% under the ten-year subsidy. This comparison reveals that the subsidy achieves a somewhat stronger retention effect in the short and medium run, largely because it directly improves farm profitability during its implementation period. In contrast, the tax operates more indirectly, through behavioral adjustment: it reduces the incentive to revert to conventional farming by raising the opportunity cost of exit, leading to a more gradual but persistent impact on long-term retention.

In sum, the pesticide tax acts primarily as a selection mechanism. It retains impatient producers in the short run by limiting early exits, but its long-term effect on this group is negligible. In contrast, the tax policy ensures full retention among patient producers. This pattern is consistent with Acs et al. (2009), who show that cost-based disincentives are most effective when they influence producer behavior through long-term selection rather than short-term financial support.

**Biophysical Risks and Pest-Related Shocks.** We now examine a scenario of intensified pest pressure, represented by a 1% increase in the severity of yield losses across all pest states, leading to new shock values of $\{0.99, 0.94, 0.59\}$. This uniform downward shift in productivity shocks represents a system-wide deterioration in the biophysical environment rather than an increase in idiosyncratic variability. In practical terms, it captures situations where pest incidence and damage become uniformly more severe across all farms—for instance, due to climate change, the spread of pest-resistant strains, or ecological conditions that favor pest survival. By scaling down all productivity states, we simulate a persistent reduction in expected yields under organic management, reflecting an environment in which farms face stronger and more frequent pest pressure while lacking access to synthetic chemical treatments.

Under this scenario, exit dynamics change markedly relative to the baseline. The most pronounced differences occur during the initial 5 years of organic production. In the first year, for example, exit rates rise from approximately 12% in the baseline scenario to 15% under




**(a)** Exit Shares

**(b)** Cumulative Exit Shares

**Figure 15:** Exit Dynamics Under Intensified Pest Pressure.

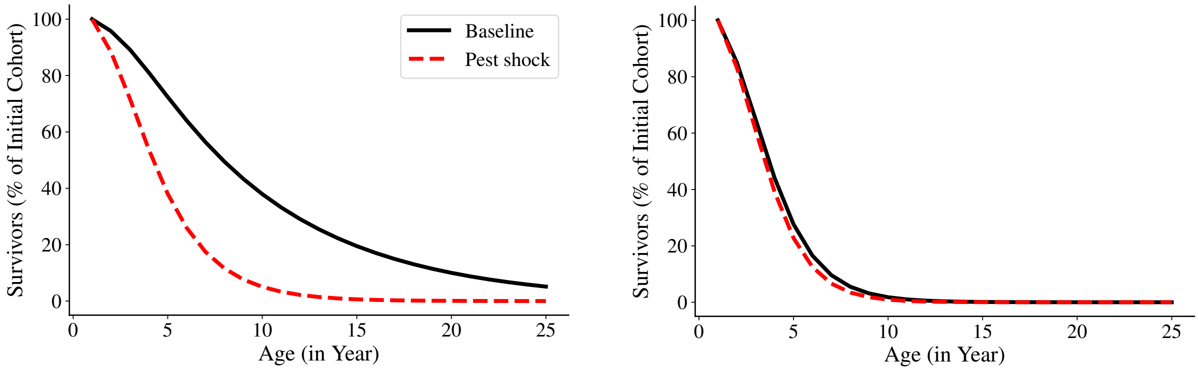
*Notes:* This figure compares exit dynamics from organic farming under baseline conditions (solid black line) and under a uniform 1% increase in pest severity (dashed red line). Panel (a) reports exit rates by age, while Panel (b) presents the corresponding cumulative exits over time.

the intensified pest pressure, and by the third year they exceed 32%, compared to 24% in the baseline. These patterns indicate that producers exposed to negative biophysical shocks on their expected productivity early in the transition phase are substantially more likely to leave organic farming.

Survival declines more sharply for patient producers than for impatient producers (see Figure 16). While impatient farmers already exhibit high exit rates under baseline conditions, the increase in pest pressure has only a marginal effect on their trajectory. In contrast, patient farmers, who typically dominate the sector in the long run, experience substantial vulnerability when pest pressure intensifies: their survival falls well below baseline levels. This indicates that even long-horizon producers cannot fully absorb the permanent increase in yield losses associated with pest outbreaks. Consequently, changes in expected pest shocks undermine the stability of the organic sector by eroding its most resilient segment, thereby reducing the long-term retention advantage of patient farmers. Unlike pesticide taxation, which reinforces selection in favor of patient producers, systemic increases in pest pressure impose risk that disproportionately affects those committed to organic farming for the long term.

These findings underscore the importance of policies aimed at mitigating biophysical risk—such as technical assistance, integrated pest management support, and crop insurance—rather than relying solely on price-based incentives or financial transfers.

Taken together, the results highlight the role of selection dynamics and the need for carefully tailored policy instruments. While subsidies and taxes can influence exit behavior, their effectiveness depends on the underlying distribution of producer types. Uniform transfers may provide temporary relief but fail to secure long-term retention. By contrast, targeted interventions—whether financial or regulatory—can better align incentives with producers' time preferences, thereby enhancing the sustainability of organic conversion.




**(a)** Patient Farmers $\bar{\theta}$ **(b)** Impatient Farmers $\underline{\theta}$

**Figure 16:** Survival Dynamics Under Intensified Pest Pressure.

*Notes:* This figure compares survival trajectories for impatient ($\underline{\theta}$) and patient ($\bar{\theta}$) producers under baseline conditions and a scenario in which pest severity is uniformly increased by 1%.

# 6 Conclusion

This paper has examined the adoption and exit dynamics of organic farming in Quebec, with a particular focus on the fragility of retention despite sustained entry. Using a novel dataset on certification records, we documented a pattern of continuous turnover: while new farms join the organic sector each year, a large share of them exit within the first five years of certification. This fragile equilibrium raises questions about the structural conditions under which organic farming can become a stable and resilient component of Quebec's agricultural system.

Our econometric analysis demonstrated that the probability of exit is strongly shaped by farm age, certification body, product type, and regional location. Younger enterprises face the highest risk of attrition, underscoring the vulnerability of the transition period. Certification by Ecocert Canada is associated with greater stability compared to other certifiers, suggesting the importance of institutional credibility and support services. Product specialization also matters: maple and livestock farms exhibit lower exit risks, while wild-harvest producers remain particularly fragile. Regional variation further highlights the role of local market access and support networks. In addition, farms with a more diversified product portfolio show lower exit probabilities, indicating that diversification serves as a buffer against the biological and market fluctuations that characterize organic production.

To interpret these findings and evaluate the role of policy, we developed a dynamic model of farmers' regime-switching decisions under uncertainty. The model incorporated heterogeneous time preferences and pest shocks, and was calibrated to replicate observed exit dynamics. Simulation results revealed that one-time subsidies reduce exit only temporarily, while sustained support over several years yields more durable retention effects. Pesticide taxation policies, by raising the relative cost of conventional farming, can discourage reversion and strengthen the organic sector in the medium term. However, pest shocks remain a major source of vulnerability, amplifying exit risks in the absence of effective risk management instruments.

Taken together, our results point to three central lessons. First, fostering adoption alone is insufficient: policies must also address the structural vulnerabilities that lead to early exits. Second, the design of support programs matters greatly—short-lived incentives may encourage entry but fail to secure long-term retention, whereas sustained and targeted assistance has a more lasting impact. Third, resilience requires policies that integrate financial support with risk management tools to buffer against environmental shocks and market volatility.

By combining descriptive evidence, econometric analysis, and a structural model, this paper contributes to the ongoing debate on the sustainability of organic farming. The findings indicate that, although Quebec has made substantial progress in expanding organic agriculture, the sector remains in a fragile equilibrium. Farms with more diversified production structures exhibit greater resilience, reinforcing the idea that vulnerability in organic systems arises not only from biological shocks but also from narrow specialization. Enhancing the sector's stability therefore calls for a policy shift from encouraging entry toward supporting long-term retention, with particular attention to the producers most exposed to recurrent shocks and limited diversification opportunities.

Future research should further investigate endogenous price adjustments—arising, for example, from pesticide tax policies—and examine the influence of consumer demand and international competition. Such extensions would offer a more comprehensive understanding of how organic farming can evolve from a fragile equilibrium into a durable pillar of sustainable agriculture.

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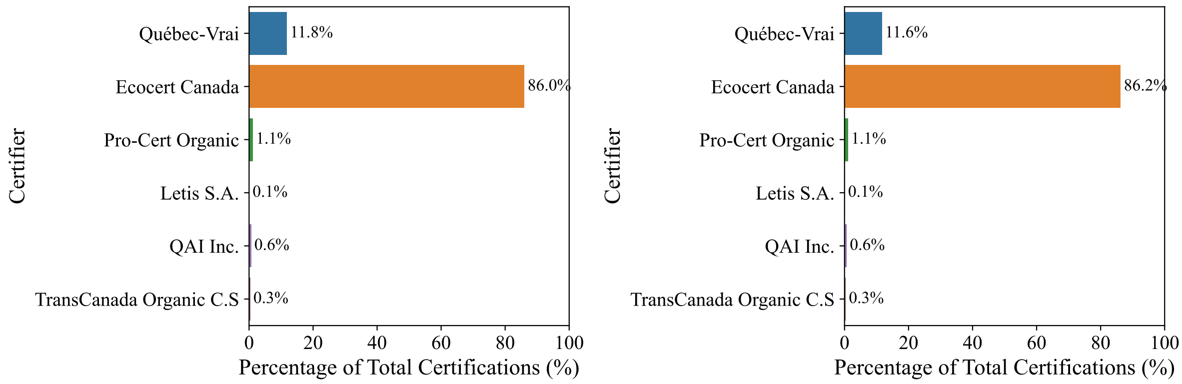
# A Appendix

Table A.1 presents the evolution of the number of enterprises holding organic certification in Quebec, as well as the sector's dynamics through annual entries and exits. These data, sourced from the Bio Québec portal, are also illustrated graphically in the article.

**Table A.1:** Evolution of Certified Organic Enterprises

| Year | Certified Enterprises | New Entries | Exits |
|---|---|---|---|
| 2021 | 3231 | 349 | 223 |
| 2022 | 3446 | 297 | 172 |
| 2023 | 3527 | 312 | 231 |
| 2024 | 3533 | 176 | 170 |

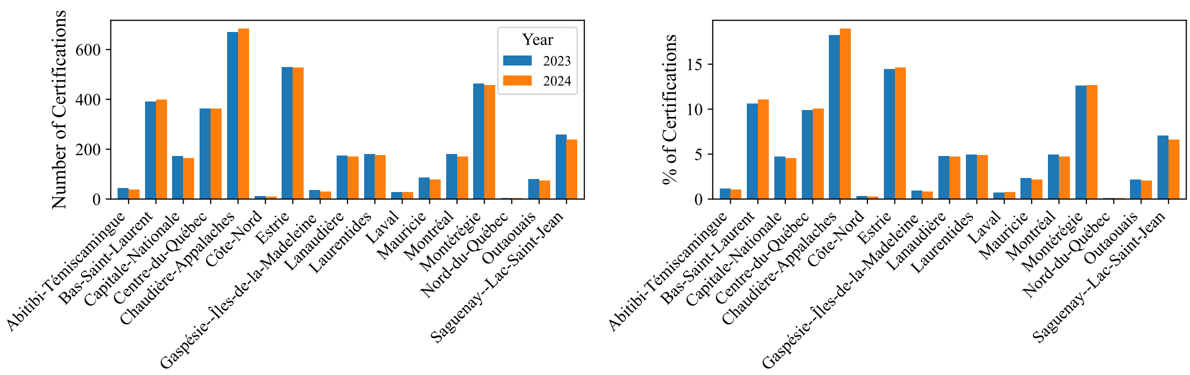



**(a)** 2023

**(b)** 2024

**Figure A.1:** Percentage of Certified Enterprises by Certifier in Quebec

*Notes:* This figure presents the share of total organic certifications attributed to each certifying body in Quebec for the years 2023 and 2024.



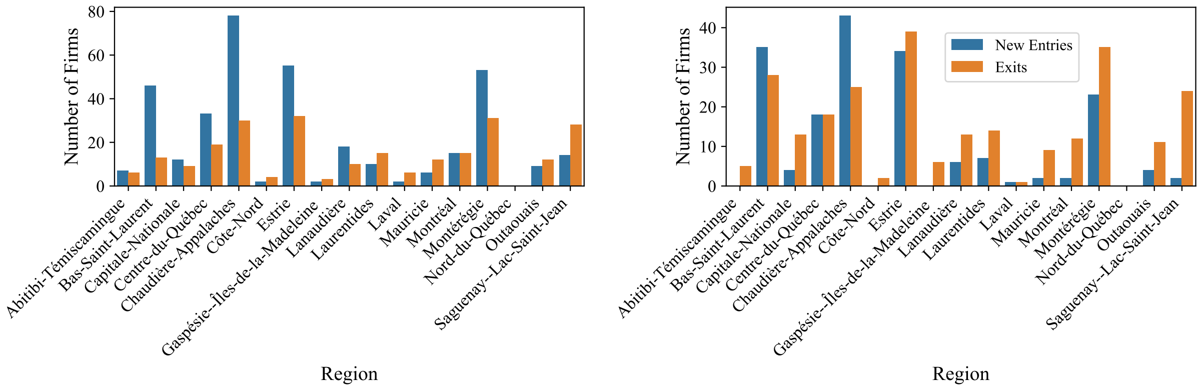

**(a)** Number

**(b)** Percentage

**Figure A.2:** Organic Enterprises Certified by Region in Quebec (2023 vs 2024)

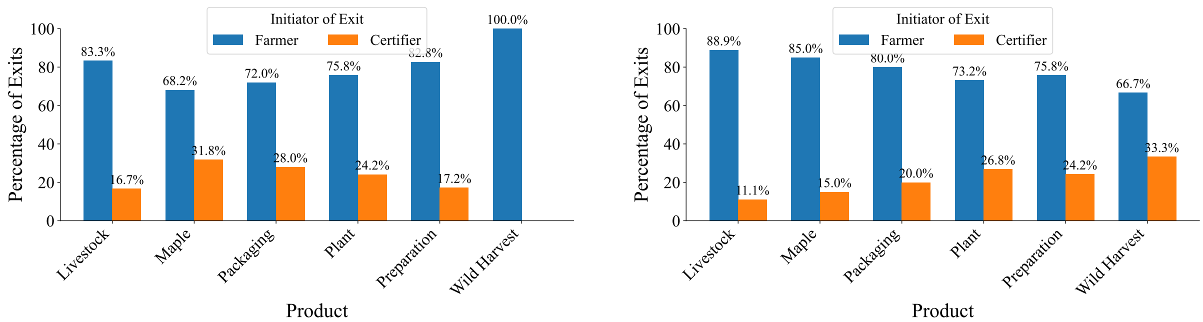
*Notes* : This figure displays the number of certifications held by organic enterprises across Quebec's administrative regions in 2023 and 2024 in Panel (a) and Panel (b) displays the percentage of certifications held by organic enterprises across Quebec's administrative regions in 2023 and 2024.

Figure A.3 illustrates the number of certified organic products held by agricultural enterprises across Quebec's regions in 2023 and 2024. The graphs highlight the heterogeneous dynamics of the organic sector within the province. In 2023, the sector experienced strong growth, with entries far exceeding certification losses. Regions such as Chaudière-Appalaches, Bas-Saint-Laurent, Estrie, and Montérégie led in certified operations. While these regions sustained similar trends in 2024, they also faced a marked increase in certification losses. By 2024, exits surpassed new entries in most regions, raising concerns about the sector's long-term sustainability.




**(a)** 2023 **(b)** 2024

**Figure A.3:** Entries and Exits by Region




**(a)** (2023) **(b)** (2024)

**Figure A.4:** Distribution of Exits by Product and Initiator

*Notes:* This figure shows the percentage of exits for each product, broken down by the initiator of the exit. The two categories of initiators are Farmer and Certifier. The vertical axis represents the share of exits (in percent) relative to the total exits for that product, scaled from 0 to 100%. Bars for each product are grouped, with the left bar representing Farmer-initiated exits and the right bar representing Certifier-initiated exits. The numerical values on top of each bar indicate the exact percentage.

**Table A.2:** Logit Regression Estimates on the Probability of Exit

| | Full Sample | | <12 months | | >12 months | |
|---|---|---|---|---|---|---|
| | Coef. | SE | Coef. | SE | Coef. | SE |
| **Firm Age** | | | | | | |
| log(*age*) | 1.613** | (0.693) | 7.317*** | (1.440) | -1.112*** | (1.156) |
| $\log^2(age)$ | -0.336*** | (0.0953) | - | - | - | - |
| **Certifier** | | | | | | |
| Quebec-Vrai | 1.230*** | (0.378) | -0.354 | (0.592) | 1.412*** | (0.332) |
| Pro-Cert Organic Systems Ltd. | 0.503 | (1.034) | - | - | 1.282 | (0.912) |
| Letis S.A. | - | - | - | - | - | - |
| QAI Inc. | - | - | - | - | - | - |
| TransCanada | - | - | - | - | - | - |
| *Reference: Ecocert Canada* | | | | | | |
| **Certified Product** | | | | | | |
| Alcohol | -0.679 | (0.903) | - | - | -0.432 | (0.851) |
| Maple | -3.416*** | (0.576) | -3.395*** | (0.908) | -3.318*** | (0.554) |
| Livestock | -1.259** | (0.520) | - | - | -1.160** | (0.483) |
| Preparation | -1.286*** | (0.463) | -2.400** | (1.107) | -1.319*** | (0.430) |
| Plant | -0.657 | (0.482) | 0.296 | (0.409) | -0.844* | (0.443) |
| Packaging | -1.092* | (0.569) | -0.711 | (0.830) | -1.191** | (0.528) |
| Wild Harvest | 2.325* | (1.225) | -0.262 | (5.576) | 2.110** | (0.9) |
| **Region** | | | | | | |
| Estrie | -0.145 | (0.469) | -0.115 | (0.706) | -0.200 | (0.471) |
| Lanaudière | -1.717*** | (0.970) | -0.393 | (1.188) | -1.809** | (0.673) |
| Outaouais | -0.026 | (0.763) | -2.811* | (1.617) | -0.026 | (0.741) |
| Montreal | -0.495 | (0.692) | 0.449 | (1.36) | -0.754 | (0.677) |
| Montérégie | -1.014** | (0.506) | -0.821 | (0.917) | -0.927* | (0.5) |
| Bas-Saint-Laurent (ref) | - | - | - | - | - | - |
| Chaudière-Appalaches | -0.715 | (0.486) | 0.415 | (0.631) | -0.971* | (0.515) |
| Capitale-Nationale | -7.444 | (0.682) | -1.526 | (1.459) | -0.737 | (0.664) |
| Saguenay–Lac-Saint-Jean | -0.321 | (0.553) | -1.762 | (1.346) | -0.287 | (0.535) |
| Centre-du-Québec | -0.758 | (0.548) | -0.382 | (0.830) | -0.900 | (0.557) |
| Gaspésie–Îles-de-la-Madeleine | 1.022 | (1.118) | - | - | 1.125 | (1.010) |
| Laurentides | -0.321 | (0.603) | -2.089* | (1.257) | -0.025 | (0.91) |
| Abitibi-Témiscamingue | 0.133 | (0.939) | - | - | 0.317 | (0.911) |
| Mauricie | 0.447 | (0.745) | 1.449 | (1.575) | 0.286 | (0.715) |
| Côte-Nord | 5.302** | (1.181) | - | - | 2.617* | (1.571) |
| Nord-du-Québec | - | - | - | - | - | - |
| Laval | 0.245 | (1.181) | -2.291 | (1.6008) | 0.187 | (1.100) |
| **Year** | | | | | | |
| 2024 | 0.211 | (0.198) | -0.716* | (0.432) | 0.199 | (0.190) |
| **Model Statistics** | | | | | | |
| Constant | -6.300*** | (1.378) | -15.258*** | (3.118) | -0.246*** | (0.870) |
| Observations | 7219 | | 483 | | 6722 | |
| Log-likelihood | -1405.98 | | -105.923 | | -1310.11 | |
| Chi² | 427.91 | | 27.35 | | 328.18 | |

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.3:** Logit Regression Estimates with Number of Certified Products

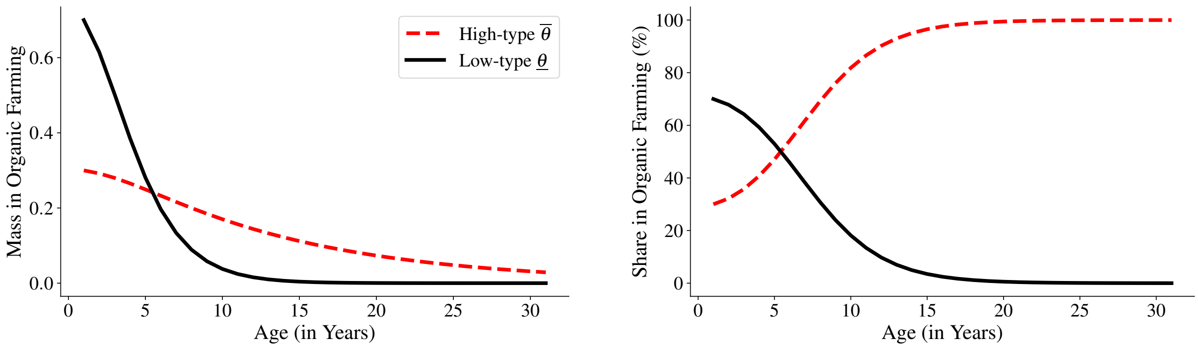
| | Full Sample | |
|---|---|---|
| Variable | Coef. | SE |
| **Firm Age** | | |
| log(*age*) | 1.762*** | (0.665) |
| $\log^2(age)$ | -0.362*** | (0.091) |
| **Certifier** | | |
| Quebec-Vrai | 1.181*** | (0.322) |
| Ecocert Canada (Ref.) | | |
| Pro-Cert Organic Systems Ltd. | 0.455 | (0.967) |
| Letis S.A. | | |
| QAI Inc. | | |
| TransCanada | | |
| **Certified Product** | | |
| Alcohol | -0.549 | (0.847) |
| Maple | -3.242*** | (0.388) |
| Livestock | -0.976** | (0.413) |
| Preparation | -0.418* | (0.218) |
| Plant | -0.247** | (0.126) |
| Packaging | -0.071 | (0.087) |
| Wild Harvest | 1.624** | (0.752) |
| Region | ✓ | |
| Years | ✓ | |
| **Model Statistics** | | |
| Constant | -6.598*** | (1.265) |
| Observations | 7,219 | |
| Log-likelihood | -1411.957 | |

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table A.4:** Logit Regression Estimates for Plants

| | Full Sample | | Excluding Maple Firms | | Only Plant Firms | |
|---|---|---|---|---|---|---|
| | Coef. | SE | Coef. | SE | Coef. | SE |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Other controlled areas | -0.2085 | (0.3551) | 0.0147 | (0.4819) | -0.7684 | (0.6769) |
| Cultivated mushrooms | 3.1297 | (2.0425) | 8.3837*** | (2.8536) | 0.6307 | (4.6028) |
| Greenhouse crops | -0.7181* | (0.4297) | -0.8055 | (0.5661) | -1.6282** | (0.7937) |
| Cereals, oilseeds and industrial plants | -3.2151*** | (0.4448) | -3.6297*** | (0.6256) | -5.0195*** | (0.8251) |
| Field herbs, aromatic plants and medicinal plants | 1.1482 | (1.0636) | 1.2867 | (1.4741) | 1.4872 | (1.9181) |
| Forages | 0.9585** | (0.3918) | 1.2029** | (0.5155) | 1.6428** | (0.7119) |
| Field fruit | -0.5517 | (0.3893) | -0.6327 | (0.5325) | -1.4358* | (0.7536) |
| Plants, transplants and seeds | -2.1219* | (1.2577) | -2.6780 | (1.6852) | -2.9940 | (2.0064) |
| Field vegetables | -0.4814 | (0.3694) | -0.5597 | (0.4970) | -1.6523** | (0.6966) |
| Region | ✓ | | ✓ | | ✓ | |
| Firm Age | ✓ | | ✓ | | ✓ | |
| Others products | ✓ | | ✓ | | ✓ | |
| N | 7219 | | 4161 | | 2197 | |
| Log likelihood | -1409.71 | | -943.12 | | -557 | |

*Notes:* This table reports the estimation results from the panel logit model after disaggregating the plant category. The specification includes all baseline covariates; however, for brevity, we present only the coefficients for variables that are directly relevant to the analysis. Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$




**(a)** Level

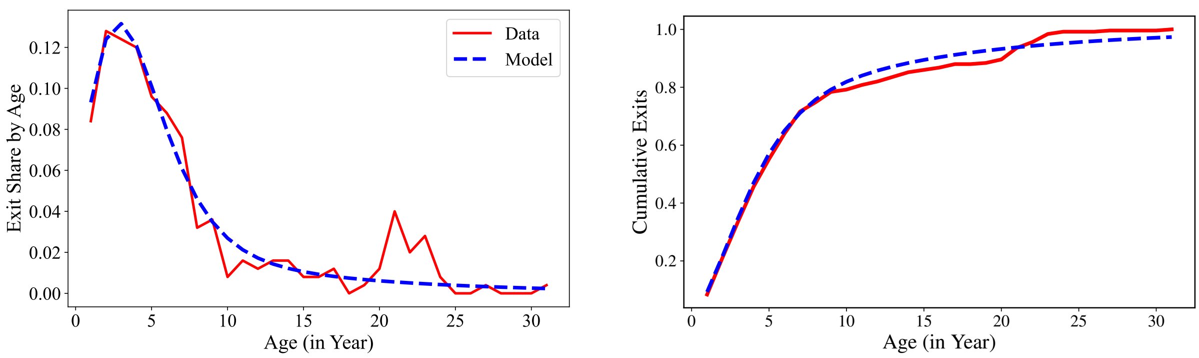
**(b)** Proportion

**Figure A.5:** Evolution of Estimated Farmer Types in Organic Farming Over Time (Using 2024 Data)

**Table A.5:** Marginal Effects on the Probability of Exit for Plants

| | Full Sample | | Excluding Maple Firms | | Only Plant Firms | |
|---|---|---|---|---|---|---|
| | Coef. | SE | Coef. | SE | Coef. | SE |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Other controlled areas | -0.0064 | (0.0108) | 0.0003 | (0.0090) | -0.0066 | (0.0064) |
| Cultivated mushrooms | 0.0954 | (0.0628) | 0.1569*** | (0.0553) | 0.0054 | (0.0397) |
| Greenhouse crops | -0.0219* | (0.0137) | -0.0151 | (0.0107) | -0.0139* | (0.0079) |
| Cereals, oilseeds and industrial plants | -0.0980*** | (0.0136) | -0.0679*** | (0.0131) | -0.0431** | (0.0152) |
| Field herbs, aromatic plants and medicinal plants | 0.0350 | (0.0325) | 0.0241 | (0.0279) | 0.0128 | (0.0171) |
| Forages | 0.0292** | (0.0120) | 0.0226** | (0.0100) | 0.0141* | (0.0766) |
| Field fruit | -0.0162 | (0.0119) | -0.0118 | (0.0094) | -0.0123* | (0.0072) |
| Plants, transplants and seeds | -0.0647* | (0.0334) | -0.0501 | (0.0317) | -0.0257 | (0.0192) |
| Field vegetables | -0.0147 | (0.0113) | -0.0105 | (0.0093) | -0.0142* | (0.0073) |
| Region | ✓ | | ✓ | | ✓ | |
| Firm Age | ✓ | | ✓ | | ✓ | |
| Others products | ✓ | | ✓ | | ✓ | |
| Number of obs. | 7219 | | 4161 | | 2197 | |

*Notes:* This table reports the marginal effect coefficients from the panel logit model after disaggregating the plant category. The specification includes all baseline covariates; however, for brevity, we present only the coefficients for variables that are directly relevant to the analysis. Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$




**(a)** Share of Exits by Age Group **(b)** Exit Probability by Age

**Figure A.6:** Exit Share and Probability Dynamics: Model vs 2024 Data

**Table A.6:** Calibrated Parameters Using 2024 Exit Data

| Parameter | Description | Value |
|---|---|---|
| $\beta^{\underline{\theta}}$ | Discount factor (low-type) | 0.775 |
| $\beta^{\overline{\theta}}$ | Discount factor (high-type) | 0.948 |
| $\gamma$ | Sensitivity to value differences | 0.005 |
| $S_0^{\overline{\theta}}$ | Initial share of high type | 0.3 |
| $\sigma_1$ | Pest-shock state 1 | 1.000 |
| $\sigma_2$ | Pest-shock state 2 | 0.95 |
| $\sigma_3$ | Pest-shock state 3 | 0.603 |

Transition matrix $\Omega$

$$\begin{bmatrix} 0.607 & 0.282 & 0.111 \\ 0.000 & 0.610 & 0.391 \\ 0.000 & 0.000 & 1.000 \end{bmatrix}$$

*Notes:* This table reports the calibrated values of the model parameters, estimated by solving the minimization problem defined in Equation (5.3) with 2024 exit data.