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Applied Economics Teaching Resources

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Applied Economics Teaching Resources

Teaching and Educational Methods

An Ignatian Pedagogical Approach to Fostering Conversations on BIPOC Farmland Ownership Through Film Screenings

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Abstract
This article applies the Ignatian pedagogical paradigm (IPP) to developing a day-long event focused on Black, Indigenous, and People of Color (BIPOC) farm ownership in a college of agriculture at a mid-south university. The event utilized IPP's five elements—context, experience, reflection, action, and evaluation—to engage students with conversations surrounding the systemic barriers adversely affecting BIPOC producers. The event included a screening of "Gaining Ground," which provided historical and contemporary insights into the challenges of BIPOC landownership, setting a foundational context and offering a direct experiential learning opportunity. The screening was followed by a panel discussion involving experts in agriculture, social justice, and policy, which deepened the reflective component of the pedagogical framework. The action and evaluation phases were highlighted through networking opportunities with leaders in the field and feedback collection to assess changes in participant perceptions and intentions to act on their knowledge. This case study demonstrates the IPP's effectiveness in delivering educational content and inspiring actionable insights and personal growth for students in agricultural colleges. It underscores the paradigm's value in academic settings for addressing complex social issues and offers a model for educators who seek to enhance student engagement and societal impact through structured pedagogical approaches.

1 Introduction

An increasing emphasis has been placed on integrating socioeconomic perspectives that reflect the diverse and complex realities of farming communities, particularly those historically marginalized (Estepp, Wiersma-Mosley, and Shoulders 2021). To address these challenges, a day-long event was organized at a mid-south land-grant university, focusing on fostering conversations surrounding Black, Indigenous, and People of Color (BIPOC) farmland ownership. The event featured a documentary screening, expert panel discussions, and networking opportunities, all designed to engage students with the systemic barriers that adversely affect BIPOC producers. This article explores one method to present systemic barriers faced by BIPOC farmers to students, an issue that aligns with the land-grant mission to address societal challenges through educational scholarship (Malone et al. 2022).

Emphasizing these barriers is critical in U.S. colleges of agriculture, given the pivotal role of diversity in enhancing U.S. food systems amid changing demographic and economic landscapes (McCluskey 2019). Despite their significant contributions, BIPOC farmers encounter multifaceted hurdles, from accessing land and capital to navigating institutional biases within agricultural support systems, resulting in a sharp decline of BIPOC-owned Farms (Horst and Marion 2019). These challenges are rooted in historical inequities and require increased intercultural competence and "anti-racism" among burgeoning agriculturalists (Wiersma-Mosley et al. 2023).

By approaching these barriers through the Ignatian pedagogical paradigm (IPP), this study contributes to a broader understanding of how educational interventions can be designed to challenge students to reflect and critically analyze how their own lived experiences might mirror or challenge their

current worldview. The IPP is a well-established educational framework rooted in Jesuit pedagogical theory, emphasizing the integration of five core elements: context, experience, reflection, action, and evaluation. Each of these elements plays a crucial role in shaping the learning process, promoting a holistic approach that encourages personal growth, critical thinking, and social responsibility. In this context, the IPP provides a structured approach to engage students deeply with the systemic barriers faced by BIPOC farmers, fostering a more inclusive and empathetic perspective. This approach is particularly relevant to developing intercultural competence for undergraduate students in the United States, as it underscores the importance of educational innovations that promote inclusivity and economic resilience in the agri-food sector (Wiersma-Mosley 2019).

Justice work is critical for the field of agricultural and applied economics (Wilson 2023). As such, this paper shows how educators, policymakers, and agricultural professionals might leverage on-campus events to foster conversations about relevance, quality, trust, diversity, equity, and inclusion in agri-food systems (Bohman 2024). These conversations are particularly important, as agri-food policy opinions have changed over time, often leading to demands for added political intervention in the food system (Biedny, Malone, and Lusk 2020). This article seeks to contribute to our understanding of important societal issues and promote innovative pedagogical shifts that might enhance accessibility and inclusion in agricultural education.

The remainder of this article is organized as follows. First, we provide a pedagogical background that describes our approach to the development of the event. Rooted in the IPP of integrated action and reflection, we describe the mechanisms with which we introduced the relevant historical and socioeconomic data that describe institutionalized barriers to entry for BIPOC farmers in the United States. We then give a detailed account of the event, including contextual and background information necessary to understand the situation. This section includes details about the event and the entities involved. The fourth section uses reflection data from students in a senior-level undergraduate agricultural economics class of seventy-five students to describe how students processed and reflected on the event. The article then concludes with learned recommendations of best practices for developing similar events in the future.

2 Pedagogical Background

Though events are common on university campuses, this article argues the importance of intentionality in developing an overarching theme and integrating a reflection process into the event. To accomplish this intentionality, we approached our event from the paradigm of the IPP approach, especially as it relates to engaging students in understanding business strategy and ethics (Van Hise and Massey 2010; Gunn et al. 2015; Mauri, Figueiredo, and Rashford 2015). Figure 1 presents our conceptual approach, which is founded on five core elements: context, experience, reflection, action, and evaluation, each contributing uniquely to the learning environment and outcomes of the event.

2.1 Context

In the IPP, the concept of "Context" plays a foundational role in shaping the educational experience, recognizing that learning does not occur in isolation but is deeply influenced by the environment in which it takes place. Context encompasses how a student's personal identity is attached to the historical, cultural, socioeconomic, and personal circumstances surrounding the learners and the learning environment (Moreno and Malone 2021). In agriculture, context is also inherently social, as social connectedness has been shown to lead to changes in production choices (DeDecker et al. 2022). It grounds the educational content in the realities of the students' lived identity, making the learning

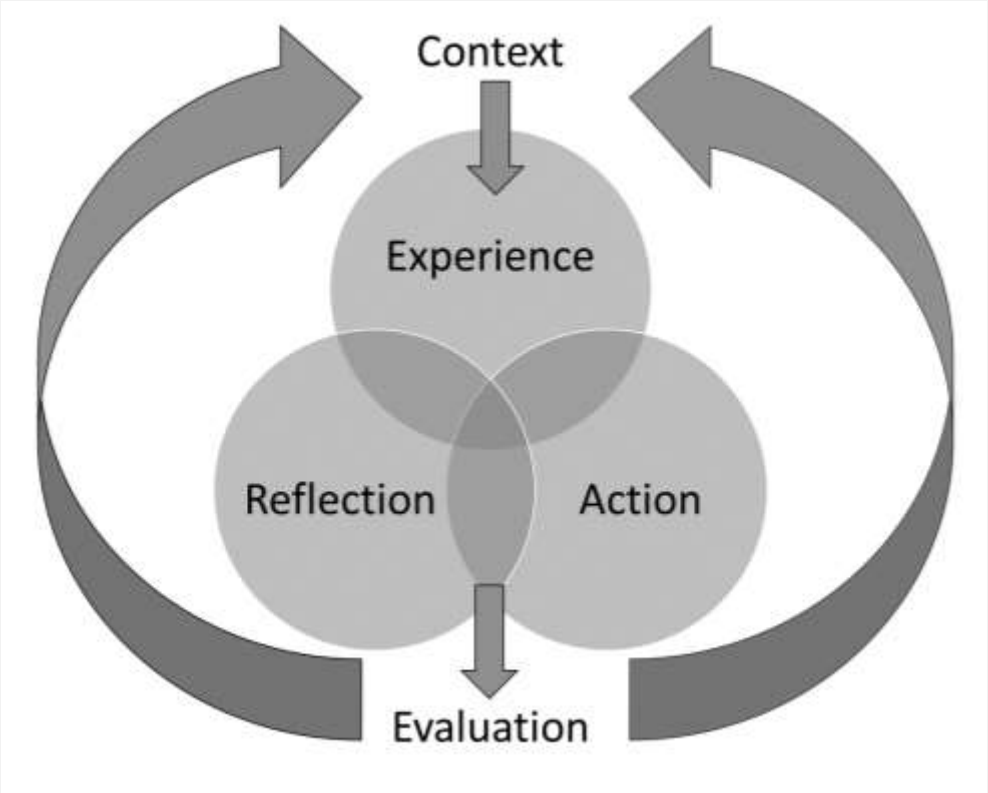

Figure 1: Ignatian Pedagogical Paradigm.

Note: Adapted from Mauri et al. (2015)

experience more relevant and impactful. By understanding the specific contexts of the learners, educators can tailor the curriculum to address the unique challenges and advantages these environments present. In strategy classrooms, particularly those dealing with complex issues such as social justice or business ethics, acknowledging context allows a deeper exploration of how broader systems influence individual and collective behaviors and decisions. This approach enhances comprehension and fosters a more empathetic and informed student body equipped to engage with the world around them thoughtfully and effectively.

The event was set against the backdrop of increasing awareness and support for BIPOC communities in agriculture, a sector marked by historical inequities. By hosting the event at a major educational land-grant institution and involving stakeholders from various sectors, including academia, industry, and civil society, the event created a rich context for addressing complex and systemic issues in land ownership and farming among Black communities.

2.2 Experience

Once "Context" is established, a student's "Experience" forms the primary foundation for deeper learning and personal transformation. This element goes beyond passive absorption of information, allowing learners the ability to engage with and participate actively in the educational content (Lagoudakis et al. 2020). Experience in this framework can range from experiential learning activities, such as simulations and role-playing, to real-world interactions and observations that bring academic theories to life. For instance, in an agribusiness management strategy classroom focusing on agricultural economics, students might conduct field visits to farms or communities, conduct interviews, or participate in service-learning projects that align with the curriculum. These experiences are designed to make the

learning process vivid and tangible, fostering a deeper emotional and intellectual connection to the subject matter. This hands-on approach helps students better understand the complexities of the topics they are studying and empowers them to apply their knowledge in practical and often innovative ways, reinforcing the Ignatian call to service and ethical action.

The documentary screening was a direct experience, providing visceral and intellectual engagement with the subject matter. The panel discussion and the interactive sessions with BIPOC farmers and educators complemented this, further enriching the attendees' understanding by connecting theoretical insights with real-world applications and personal narratives.

2.3 Reflection

"Reflection" is a vital component facilitating a deeper internalization and understanding of the knowledge gained through experience. Without a thorough process of reflection, people can make kneejerk reactions, creating inappropriate policy decisions, thereby misallocating public resources (Malone, Schaefer, and Wu 2021). In this setting, reflection acts as a bridge connecting experience to learning, allowing students to process and analyze their experiences critically. This process encourages students to consider what they have learned and how it applies to their values, future actions, and broader societal impacts. In an educational setting, structured reflection might involve discussions, journaling, or reflective essays that prompt students to think about the ethical dimensions of their studies, challenge their preconceptions, and synthesize disparate pieces of knowledge into a coherent whole. This reflective practice is particularly important in fields engaging in topics like social justice, where understanding the subtleties of cause and effect, ethical implications, and long-term consequences is crucial (Hendricks et al. 2024; Sant'Anna, Kim, and Demko 2024; Yu and Lim 2024). By fostering a habit of reflective thinking, IPP helps students develop a more thoughtful, proactive, and compassionate approach to their personal and professional lives. Reflection was facilitated through guided discussions and Q&A sessions that followed the documentary screening and during the panel discussion. This phase allowed participants to digest and analyze the information presented, consider various perspectives, and engage with complex topics more deeply, fostering a critical examination of the issues at hand.

2.4 Action

The natural progression from "Reflection" is "Action," embodying the principle that learning should increase knowledge and inspire a commitment to making a positive impact. This component encourages students to apply what they have learned in practical, often transformative ways, bridging the gap between theory and practice. Action in this context can take various forms, from community service projects and advocacy work to implementing new business strategies or policy recommendations. For example, students studying environmental policy might organize a local conservation initiative, or those in business ethics could develop fair trade partnerships. This active engagement ensures that education is about personal enrichment and contributing to the common good. By emphasizing action, IPP fosters a sense of responsibility and agency in students, urging them to become leaders who act conscientiously and ethically in their personal and professional lives, driven by a well-formed conscience to effect change in the world around them.

The actionable component was emphasized through discussions on strategic approaches to address the challenges faced by BIPOC farmers, including legal, economic, and social strategies. Involving students and future policymakers sought to inspire other participants to contribute effectively to these strategies.

2.5 Evaluation

To close the learning loop, participants must have an opportunity for "Evaluation" via a systematic assessment of the educational process and its outcomes. This evaluation extends beyond traditional academic metrics to include reflective self-assessment, peer feedback, and the actions' real-world impacts. It is designed to gauge what the students have learned, how they have grown personally, and how effectively they have applied their learning in practical contexts. This process encourages continuous improvement and personal development, helping students to recognize their strengths and identify areas where further growth is needed. In practice, evaluation might involve revisiting learning objectives to ensure they align with the outcomes, adjusting teaching methods based on student feedback, or analyzing the community impact of a service project. By incorporating comprehensive evaluation methods, IPP ensures that education is dynamic, responsive, and deeply transformative, encouraging lifelong learning and adaptation.

Although not immediately quantifiable during the event, the evaluation phase involves an ongoing assessment of the knowledge disseminated and its impact on the participants' understanding and actions post-event. This would ideally be measured through subsequent engagements, applications of learned concepts, and perhaps follow-up sessions or surveys to gauge the long-term impact of the event.

By integrating these elements, the event aimed to inform and engage students in a novel way, equipping students with the knowledge, insights, and motivation to effect change. This approach aligns with the IPP's goal of forming well-rounded individuals aware of societal issues and prepared to take thoughtful and effective actions to address them.

3 Event Description

In the Spring 2024, an agricultural college at a mid-south, land-grant university hosted a full-day event titled "Transcending Spaces: A Community Conversation of Gaining Ground, The Fight for Black Land." This event was developed in collaboration with its Minorities in Agriculture, Natural Resources, and Related Sciences (MANRRS) chapter and supported by a local art museum. This event was developed to address the value of contextualizing and facilitating class conversations about campus diversity, equity, inclusion, belonging, and social justice (Saucier et al. 2023).

The day began with lectures during courses in the agricultural economics department. In alignment with the IPP's emphasis on "context," a Black farmer led an informal discussion with a senior-level Farm Business Management class, sharing insights from his extensive experience as a fifth-generation farmer and agricultural leader. His discussion focused on innovative farming techniques and sustainable practices that have been instrumental in the success of his farms in Virginia and Arkansas. He elaborated on the importance of community building within the agriculture sector, especially among Black farmers, and he also highlighted the National Black Growers Council. His lecture covered strategic decisions in crop selection, land management, and leveraging agricultural technology to enhance productivity and sustainability. By integrating his personal journey and professional challenges, he gave the students a comprehensive view of modern farm management, emphasizing resilience and adaptation in the face of evolving agricultural landscapes. This lecture enriched the students' academic experience and deepened their understanding of the socioeconomic factors influencing contemporary farming.

In a second course, a Black farmer described the opportunities and challenges in his entrepreneurial role as co-founder of the only minority-owned U.S. farm-to-bottle distillery to a junior-level Food and Agricultural Marketing class. The lecture dovetailed with a larger in-course conversation about the importance of marketing strategy selection for small-scale agricultural producers in the southern United States (Popp et al. 2023). Drawing from his nontraditional experience of transforming a sweet potato farm into premium spirits, he illustrated the role of branding and niche marketing in the success of agricultural enterprises. He emphasized the importance of storytelling in connecting

consumers with the heritage and quality of local produce, which has been pivotal for his family distillery. The lecture covered key strategies such as identifying target markets, leveraging social media for brand visibility, and fostering customer loyalty through community engagement. His insights gave the students practical examples of how innovative marketing strategies can elevate agricultural products from commodity status to premium brand offerings, thereby adding significant value to farm produce. By bringing the speakers to class and meeting the students where they regularly learn, we provide a solid grounding in our students' context, as outlined by the IPP, to set the stage for deeper experiential learning.

Before the documentary screening, we hosted an invite-only BBQ, catered by a BIPOC-owned local food business, where more than eighty Junior MANRRS students (primarily sixth- to twelfth-grade students) and educators from a rural community could informally engage with campus and agricultural leaders in a relaxed atmosphere, fostering conversations before the documentary and panel discussion. This gathering was designed with the IPP's "context" element in mind, creating a setting that acknowledged the backgrounds, identities, and experiences of the participants, particularly those who had never visited a college campus before. Junior MANRRS is a pre-collegiate initiative designed to foster interest and prepare young students for future careers in the fields of science, technology, engineering, agriculture, and mathematics (STEAM). Aimed at grades 6-12, Junior MANRRS encourages young scholars to pursue higher education and careers in agriculture, natural resources, and environmental sciences. The BBQ and interactions at this event served as an "experience" within the IPP framework, offering students a hands-on, immersive opportunity to connect with mentors and professionals, thus bridging the gap between theoretical interest and real-world application.

Junior MANRRS (1) provides an opportunity to increase historically underrepresented students' direct exposure to a land grant university and mentorship via MANRRS collegiate members; (2) improve diversity in underrepresented areas of agriculture and related sciences by dispelling agriculture "myths"; and (3) expose underrepresented students to important "soft skills", applied research, and opportunities to network with agricultural leaders (Scales et al. 2023). This exposure, coupled with the reflective conversations that occurred during the BBQ, aligns with the IPP's emphasis on "reflection," allowing students to process and internalize their experiences in a supportive environment. The program offers a range of activities, including workshops, competitions, and regional cluster and national meetings, which provide professional development opportunities and expose students to the practical and academic aspects of agricultural sciences. Junior MANRRS equips students with valuable academic and leadership skills. MANRRS introduces young scholars to a network of professionals and like-minded peers, promoting diversity and inclusion within the agricultural sector. Through this initiative, K–12 and collegiate students gained insights into the relevance of agriculture and its impact on their daily lives, encouraging them to explore and contribute to the field proactively. Guided by the IPP framework, students gained insights into the relevance of agriculture and were encouraged to take "action" by actively participating in the field and considering how they might contribute to its future.

The largest component of the event was a free screening for the campus and community of the documentary "Gaining Ground: The Fight for Black Land," which addresses the challenges and systemic injustices Black farmers have faced in the United States over the centuries. Directed by Eternal Polk, produced by Al Roker Entertainment, and supported by John Deere, the film explores the historical context and current realities of Black landownership, emphasizing the significant decline in Black-owned farms and land over the last century. This documentary screening was selected to serve as a way to engage students in "action" within the IPP framework, providing attendees with challenging information about the systemic issues embedded within BIPOC agricultural landownership. Through personal stories and expert interviews, the documentary highlights how discriminatory practices, such as the exploitation of Heirs' Property laws, have systematically disadvantaged Black landowners. It also covers the resilience and efforts of Black farmers to reclaim their land and secure their rights to sustainable farming and generational wealth. The film sheds light on past grievances and focuses on

contemporary movements and legal reforms to rectify these long-standing inequities. "Gaining Ground" advocates for equity and justice within the agricultural sector and underscores the importance of land ownership as a pillar of economic stability and cultural heritage in the Black community.

Following the documentary, the event transitioned to a panel discussion. This part of the evening brought together a diverse group of experts, each offering unique insights into the themes presented in the film. This transition to a panel discussion aligns with the IPP's emphasis on "experience" and "reflection," as it provided participants with the opportunity to engage with the material presented in the film through direct interaction with experts. The panel included the Vice President for Agriculture within the state, who brought a deep understanding of agricultural policy. The Assistant Vice President contributed his expertise in economic development and finance as well as growing up in a Black farming family in the state. A Black farmer featured in the documentary and the Chairman of the National Black Growers Council shared personal experiences and broader advocacy efforts. A Black woman who is the Founder and CEO of Black Women in Ag highlighted challenges and opportunities for Black women in agriculture. A MANRRS graduate student at the residing university provided an early career perspective. The Director of Inclusion and Belonging from an art museum moderated the panel, whose expertise ensured a dynamic and comprehensive dialogue. Her facilitation encouraged a deep dive into each panelist's thoughts and experiences, weaving together the historical contexts with contemporary issues in land ownership and agricultural practices. By anchoring the event in this historical context, we used the IPP framework to ensure that participants can engage with the content on a deeper, more informed level, setting the stage for the subsequent experiential and reflective components of the event.

Following the panel, a Black farmer who owns the only minority-owned distillery in the state hosted a private over-21 tasting. This exclusive session offered a unique opportunity to sample spirits directly from his family-owned distillery, known for its distinctive products derived from locally grown sweet potatoes and other more traditional crops cultivated on their family farm. This tasting session served as an "action" phase within the IPP framework, as it provided participants with a tangible, real-world experience that connected the theoretical and reflective components of the event to practical, lived realities. The tasting also allowed participants to appreciate the distinct flavors of the distillery's offerings and provided a deeper understanding of the agricultural and entrepreneurial spirit behind their family-owned distillery. He shared insights into the craft of distilling and the importance of agricultural innovation, making the tasting a rich, educational experience that complemented the overarching themes of the event. This session exemplified the integration of agricultural heritage with modern, sustainable practices that define the new generation of Black-owned agribusinesses.

This comprehensive event educated its participants about Black landowners' past and present struggles and increased awareness for students, educators, and professionals. Through the combined efforts of a documentary screening, expert panel discussion, and community networking, "Transcending Spaces" exemplified the value of enhancing educational and social understanding among its academic community and beyond, setting a standard for how educational institutions can address and illuminate crucial societal issues.

4 Event Reflections

Seventy-five students from a senior-level undergraduate agricultural economics class were required to attend the documentary and panel event and then write a reflection about what they learned. Most students identified as White/Caucasian, and approximately half identified as male. The primary institution of data collection granted Institutional Review Board approval. The student reflections were collected (n = 39) and analyzed using thematic analysis, a method used for identifying and analyzing patterns or themes (Braun and Clarke 2019). Study authors conducted "chunk coding," in that the authors discussed the student reflections to discover the implicit, initial patterns to form general classifications of the relevant topics to be coded (Ferrari et al. 2009). Then, following the initial coding,

codes were reviewed and discussed to determine dominant themes, and then they were categorized to reflect the perceptions of the students concerning their experiences with the event. Thematically descriptive quotes were used to demonstrate final themes, emphasizing findings across the reflections (Braun and Clark 2006).

The topics emerged from the student reflections under the five core elements: context, experience, reflection, action, and evaluation. Starting with context, the primary theme that emerged was Unawareness (which was noted in twenty-five student reflections) with most students noting that they had no idea, or previous history or knowledge, about many of the issues that were discussed in the film related to Black farmers. Many students wrote about how surprised they were, or what they had previously assumed, but discovered new information. One female student wrote: "*I assumed that Black-owned farmland was diminishing because of lack of interest in the industry. I had no idea that it was actually because of the USDA and policy that African Americans had to leave their land.*" A male student wrote: "*It never occurred to me that African Americans wanted to farm as a collective; I just assumed that these people didn't want to farm due to the racism that farming has behind it in the United States.*" Finally, many students wrote similar statements of "*I learned many interesting views and opinions I did not grow up having.*"

Next, a major theme that students wrote about was regarding their *Own Experience* (six students) within agriculture and how it related to the film. For example, one student wrote: "*I remember growing up and hearing my great-grandfather tell my brother and me [about] this. I never truly understood how important it was to own land until recently."* A male student wrote: *"I have grown up around farming my whole life and never once seen or met a Black farmer. Watching this screening showed me just how disproportionate the land ownership between Black and White people is. Looking back I can understand why this is the case."* Another student wrote*: "I agree with them that we should keep our family farms, me being raised on one, that land means a lot to me, and I could not imagine my grandma ever selling it because she wants my parents to be able to enjoy it."* One male student reported a previous experience with land loss: *"I related to this documentary when it comes to losing land that has been in the family for years. I grew up in a 2,000-acre outdoor oasis until my sophomore year of college because the land was divided between family members. In my eyes, no amount of money could have ever compared to the value of that property. I can't imagine watching a piece of ground that my family had called home for generations being taken from me completely unjustified just because of the color of my skin."* Last, one student reflected: *"My father is a row crop farmer in Arkansas. Growing up and living on my family farm is a part of who I am. I do not think I quite realized the low number of Black farmers with large farms still farming across the whole United States today. It amazed me to see the man [in the film] had no idea there were other thousand-acre farmers in the United States."*

The next theme that derived from the student reflections was in regard to their overall reflections about what they *Learned* (five students), often citing various new facts that they learned from the film. For example, a female student wrote: *"I was surprised to learn that there are more bald eagles in the United States than there are Black-owned farms, which highlights the disparity in land ownership among different ethnicities."* Another student wrote: *"Some facts I learned that I found to be very interesting were that after the Civil War, Whites terrorized the head of households, most likely lynching them, until they fled their land. The KKK would burn landowners' property and houses, and vandalized tractors until Black farmers had nothing left. Loans would be delayed for Blacks until it was too hot/late to get a good crop in, leading to no money being made, and the land going up in foreclosure. And in 1920, 16 million acres of farmland was farmed by Black farmers and now only 2 million acres are still farmed by them."* A female student was surprised to find out that: *"At one point, there were more bald eagles in the lower 48 than there were Black row crop farmers."* Critical thinking emerged for one female student: *"I never asked myself, why is it more common to hear of seventh-generation farmers from the White community but not the Black."*

Next, seven students noted the importance of *Action* and doing something to eradicate these issues; for example, one male student wrote: *"There needs to be something done; better education/information on agriculture and more land ownership opportunity could help this problem."* Another student indicted: *"I do not understand why this is not a more discussed topic in the agriculture community, and I think that this film will help bring attention to this issue and history."* A female noted: *"To me this story stuck out to me because you hear so much of these sad stories, but often times they aren't in an ag [agriculture] environment."* Finally, a male student wrote: *"Regardless of how you feel about reparations, I feel that the government could have stepped in sooner to provide clarity to this situation. The situation at hand is something that requires a lot of thought and consideration to do right by the American people."*

Finally, evaluations emerged from the student reflections in two areas: *Resiliency* (three students) and *Empathy* (five students). Resiliency was discussed by some students, for example, a male student wrote: *"Even the resilience and determination of Black communities emerged as a key issue, as they organized unions, formed unions, and fought tirelessly to defend their land rights."* Another male student wrote: *"Another captivating point in Gaining Ground is its focus on community resilience and collaboration. The film showcases how these farmers not only cultivate crops but also cultivate relationships within their local community. Through initiatives like community-supported agriculture (CSA) programs and farmers' markets, the documentary illustrates the power of community support in sustaining small-scale farming operations. This emphasis on collaboration and mutual support fosters a sense of connection and shared responsibility for food production, fostering a more resilient and interconnected local food ecosystem. Overall, "Gaining Ground" serves as an inspiring narrative of hope and resilience, demonstrating the vital role of small-scale farmers in shaping sustainable food systems and fostering community well-being."* Many students developed *Empathy* as a result of viewing the film, with one student noting: *"I feel like after watching this documentary, not only do I have an understanding of the history of agricultural land in America as a whole but an appreciation for the value of it. This film gave me a better understanding of what all farmers face on a daily basis but an even better grasp on the challenges that Black farmers face. I appreciate the opportunity to grow my knowledge base and further my respect for farmers everywhere."* A male student wrote: "*The hardships that his* [Black farmer in film] *ancestors must have undertaken is very remarkable; this shows that they were not willing to give up easily. I enjoyed this film and would like to hear more about* [these speakers'] *stories sometime, I know they are proud of the progress they have made and it does not look like they plan on slowing down anytime soon."* Finally, a male student wrote: *"Sitting in that theater and watching that movie from a different perspective was interesting. I hope to continue to learn about this process and the way of life that these families are trying to seek. Lastly, I found out that many of these farmers farm close to where I grew up and farmed around Pine Bluff, AR. I think the documentary was well put together and did a great job in expressing their message."*

The reflections gathered from students reveal a shift in awareness and understanding of how systemic barriers have been historically confronted by BIPOC farmers. This shift demonstrates how the IPP framework can foster intellectual engagement as well as a meaningful reflection on ethics. By contextualizing this documentary screening through the stages of context, experience, reflection, action, and evaluation, the event allowed them to be challenged by complex social issues. For educators, the integration of IPP in analyzing this event highlights the value of applying pedagogical frameworks to educational settings, particularly in enhancing intercultural competence and promoting social justice. In our case, the IPP provided a structured yet flexible approach to deepening student understanding and inspiring a willingness to be challenged by potentially uncomfortable course content.

5 Conclusion

This study demonstrates a unique way to expose students to the systemic barriers faced by BIPOC farmers in the United States, highlighting the historical and ongoing challenges that obstruct their access

to land and capital. By integrating the IPP, we provided an educational framework that illuminated these issues and fostered a dynamic discussion among participants, encouraging a deeper comprehension and engagement with the material.

One reason that the IPP approach may be effective is because it allows students to learn through awareness, interactions with different people, and experiences within a community. The reflections from students attending the event primarily focused on developing new awareness for issues in agriculture, ones that they were not developing through their agricultural curriculum. Increasing awareness regarding BIPOC farmers and producers is essential to agriculture because students are expected to work productively with individuals and families who have been shaped by different values, beliefs, and experiences. Not only does creating greater awareness help students with different backgrounds and needs succeed, but it encourages acceptance and helps prepare students to thrive in a diverse world. It is important to note that no course or discipline can cover all aspects of these conversations and topics. Therefore, it is important that land-grant agriculture colleges systematically review their curriculum, assessment, policies, and environments to engage students to become self-aware, recognize inequities, talk intentionally about them, and act to transform curriculum, instruction, and policy (Wiersma-Mosley et al. 2023).

While our findings contribute valuable insights into the complexities of racial inequities in farming, they come with limitations. First, though this event engaged students with concepts they might not confront in other course curriculum, there would likely be additional value by extending the limited time frame of this day-long event into a more structured "service-learning" experience (Wiersma-Mosley and Garrison 2022). Similarly, this event represents an abbreviated experience for students. The pedagogical approach typically requires a longer-form cyclical relationship between action and reflection that might be included in a longer-form "empathetic course design" structure (Saucier et al. 2022). Additionally, our focus on a specific educational setting may limit the generalizability of the conclusions. For example, the impact of the same event at an 1890s land-grant institution might create a unique value proposition (Wilson et al. 2024).

This study provides a structure for thinking about pedagogy that creates a way for students to consider the unique challenges faced by BIPOC farmers. Policy measures that ensure equitable access to resources, fair legal protections around land ownership, and targeted financial support could substantially mitigate the barriers identified. However, implementing such policies requires awareness that those problems exist. We hope to move the dialogue toward deeper discussion of policy outcomes by engaging with these concerns in a university setting. Further studies could explore the causal relationships of specific policies on BIPOC land ownership and operational success, possibly through longitudinal studies or expanded geographical scopes. That said, this groundwork paves the way for a comprehensive follow-up study, potentially incorporating a broader array of BIPOC voices from different agricultural sectors and regions to enhance the external validity of these conclusions.

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Teaching and Educational Methods

Using NetLogo to Build an Agent-Based Model for Teaching Purposes at the Graduate Student Level

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Abstract
Scholars and educators in agricultural economics face changing paradigms moving toward system-wide studies. Complex issues often involve quantitative and qualitative approaches, and it is difficult to access or acquire user-friendly tools that integrate both approaches. Agent-based modeling (ABM) offers a unique supplement to more conventional system-wide modeling frameworks, such as supply chain models, circular economy models, or coupled human and natural system models. The purpose of this paper is to show educators and graduate students about how agent-based models can be used in a graduate program curriculum. The paper shares some insight about the concept and sample applications of ABM, a popular analytic tool to study system-behavior-decision consequences through the interactions of entities. We use an example of simulating a buyer-grower market interaction for poultry products to demonstrate step-by-step strategies of using the NetLogo program to create an agent-based model. The benefits of using agent-based models include flexibilities of generating micro-level assumptions to approximate macro-level activities and outcomes, and the comprehensive integration between quantitative and qualitative analyses. The challenges are at the beginning phase to comprehend the scope and scale of analysis, define proper agents and behavioral characteristics, and generate meaningful interactions among agents in a logical manner.

1 Introduction to Agent-Based Models

The field of agricultural economics has expanded significantly to involve complex factors while examining various systems such as food systems (e.g., Fresco et al. 2021), health systems (e.g., Norton, Alwang, and Masters 2021), environmental systems (e.g., Fezzi and Batemen 2011), and many others. Several analytical tools have been developed to accommodate the needs to incorporate interactions, feedback, decisions, circularity, and consequences across actors within a system or linking multiple systems (Velasco-Munoz et al. 2021; Monti et al. 2023). An agent-based modeling (ABM) system is a computational process for researchers to simulate interactions and dynamics between diverse sets of agents. ABM is generally synonymous with multiagent-based modeling, multi-agent systems modeling, and agent-directed modeling (e.g., Oren et al. 2000). Simulations that take an ABM approach have gained popularity in the social sciences, due to its wide variety of applications that allow for an agent's decision making to be represented in ways that are context-dependent and easy to manipulate (e.g., Gilbert 2019).

The characteristics of an ABM are fundamentally different from other popular modeling structures, such as variable-based approaches, given the nature of using micro-level assumptions to approximate macro-level outcomes (Van Dyke Parunak et al. 1998). Several modeling paradigms exist among ABM specifications, requiring the researcher to choose which option would be the best for specific research purposes. Selecting a paradigm may depend on how the modeling system characterizes time (continuous or discrete), scale (macroscale or microscale), and the desired purpose of study (outcome-oriented or process-oriented). Given the unique strengths of ABM, it would be valuable to

provide an overview of this tool for educators and graduate students in order to acquire some information/applications about ABM and how to incorporate them into graduate curricula. In this paper, we will explain the fundamental aspects of ABM, discuss the value in integrating ABM learning into graduate programming, introduce NetLogo (an ABM program) as an example for graduate-level teaching purposes, and outline a demonstration of how to apply NetLogo to simulate producer-buyer market interactions within an ABM concept. Finally, some challenges of this approach are discussed.

2 Background. What Is an ABM?

There are *three primary elements* that compose a typical ABM: (1) the selected agents, (2) the specifications and rules of how those agents interact with each other and with their shared environment, and (3) the specifications of the environment itself (Klügl and Bazzan 2012). Stemming from the world of artificial intelligence (AI) and the belief-desire-intention (BDI) framework, *an agent* is an entity that has its own set of beliefs about itself and its environment, its own set of desires that it wants to preserve, and its own set of intentions for what it is trying to accomplish (Singh, Padgham, and Logan 2016; Abar et al. 2017). The greatest strength of ABM is that it allows the researcher to focus on interactions and behaviors of the agents in the system, rather than solely focusing on overall global outcomes within the environment. This bottom-up, rather than top-down, nature is the ABM system's defining feature (Epstein 2012).

While acknowledging the difference between ABM and other modeling systems, ABM typically is most appropriate for analyzing systems with a specific set of characteristics (Hare and Deadman 2004; Klügl and Bazzan 2012). Some key characteristics are as follows: (1) systems that integrate intelligent human behavior, (2) systems that focus on the interactions between individuals and populations, (3) systems that incorporate evolutionary or changing dynamics among the selected agents, (4) systems that have multiple discrete levels where the researcher may want to analyze how each level interrelates, and (5) systems that need heterogeneous rather than homogenous behavioral rules, which is assumed in many model systems. For example, general equilibrium-based models often use homogenous representation and rely on strong, and perhaps unrealistic, assumptions about the uniformity of geographic space, rational decision making and human behavior, and presence of perfect information.

2.1 Impact of ABM on Graduate Student Development

We propose ABM as an excellent teaching support tool for graduate education in fields both in the natural and social sciences. Given the requirement for users to have at least foundational experience and skill in computer science and programming, we recommend introducing ABM materials at the graduate level, despite some claims of benefit to introducing ABM at the undergraduate level (Shiflet and Shiflet 2014). We see value in graduate students being exposed to ABM techniques in the classroom for two primary reasons. First, it will provide students with a domain to engage with interactive materials through active learning. Second, exposure to ABM can act as a starting point for graduate students to enter the world of graduate-level research by using ABM techniques as a focal point in their research projects.

Axtell and Farmer (2022) describe how graduate training in economics and finance typically relies on traditional learning pathways via reading text, whereas students often have different learning styles. Introducing activities in the classroom that make use of ABM programs offers a new learning style for instructors to convey economic ideas in a more illustrative context, while allowing students to interact with the model and examine ideas, such as through "what if" scenario analysis. Agent-based economies, even at a microscale, would offer students chances to tweak parameters and test hypotheses to see how actual economies function. Specific topics, such as supply and demand, can be visualized in real time as the model runs. Several other economic models do not offer the ease-of-use or versality that would be required for implementation in the classroom (Axtell and Farmer 2022). Computable general

equilibrium models are more complex and have been critiqued for being "black boxes," which is not conducive to be presented in a learning environment (Devarajan and Robinson 2002). Dynamic stochastic general equilibrium models often are not accessible to new users due to the steep learning curve for using them (Junior and Garcia-Cintado 2018). The functionality of ABM, paired with its emphasis on visuals, lets instructors show theories in practice in a novel and intuitive way compared to more traditional methods of knowledge transfer.

Exposure to ABM in the classroom can also offer a bridge toward helping graduate students develop their research projects. Modeling and simulation have gained legitimacy as an established research basis in graduate education, even for students with a limited background in quantitative analysis (Mielke et al. 2009; Carsey and Harden 2015). Murphy et al. (2020) praised ABM for graduate research for two reasons. First, ABM development teaches transferable skills, including programming, experimental design, and data management. Second, it provides research autonomy to the student, giving flexibility in designing and fulfilling their research project. In addition to exposure in the classroom, we see supervisors as having a critical role at teaching their students about ABM as a potential focal point of graduate research, given supervisors significant capacity in assisting in their student's research aims and success (Platow 2012).

2.2 Application Areas of ABM

The first study to directly account for individuals in a simulation was conceived in 1969 when economist Thomas Schelling analyzed ways in which neighborhoods can naturally segregate themselves by assigning characteristics to each household (which are acting as individuals). By assigning rules that households tend to want to be near other households with similar characteristics, the simulation revealed a mechanism for how a phenomenon such as segregation may occur in the natural world. Since Schelling created the first ABM in 1969, the world of ABM has expanded in scope and scale. The valuable properties of taking an agent-based approach started to gain notoriety near the turn of the century, when it was deemed to be a "revolutionary development" within the social sciences (Bankes 2002).

Several subfields within the social sciences, such as economics, political science, epidemiology, and sustainability science, have applied ABM. Economists have noted that conventional models are excellent aids for assessing the economy during times of stability. In these circumstances, equilibriums are normal, and assumptions about human behavior and rationality are usually accurate. However, in times of economic crashes or crises, there is no longer an equilibrium for a model to be based off of, and human behavior and rationality fluctuate. In this case, bottom-up approaches, such as ABM, are more suited to handle this level of complexity than conventional top-down models by being able to capture irrational or non-normal systems behavior (Tesfatsion and Judd 2006).

ABM within the domain of agricultural economics and agricultural policy began to proliferate after 2008 when seminal publications in the field gained distinction (Kremmydas, Athanasiadis, and Rozakis 2018). Two early adopters of ABM in agricultural economics were Balmann (1997), who used a cellular automata approach to observe how farms competed for land and capital in a regional geospatial environment, and Berger (2001), who measured the interactions between farms, the local economy, and regional hydrologic processes to understand resource use changes for irrigation practices and what this means for policy. These papers were innovative for two reasons. First, they explicitly modeled farm's interactions to explore structural change, such as optimal directions for a farm to scale up or down, or to enter or exit the business. Second, they added a spatial dimension, which was uncommon in traditional modeling techniques at the time.

Brady et al. (2009) used a spatial ABM approach to understand the effects of reforms to the European Union's (EU) Common Agricultural Policy in 2003, which altered how farmers received payments and benefited from agricultural support structures. Freeman, Nolan, and Schoney (2009) expanded upon Berger's use of ABM to explore agricultural structural change by simulating agriculture on a much larger scale over the course of 1960–2000. Happe et al. (2009) re-examined the reforms of

the Common Agricultural Policy by creating a model to analyze how changing payment structures can influence succession rates and exit strategies among single-holder farm operators. ABM has been increasingly applied in agricultural studies due to the ability to perform dynamic comparative analysis compared to static equilibrium farm models. This ability allows for modeling of dynamic variables, such as farmer and consumer behavior, changing markets, and resource availability. It also allows for bridging social and environmental elements (Kremmydas et al. 2018). While many more examples of ABM use in agricultural economics exist, we have chosen to highlight a few of the most impactful examples. For a more exhaustive list, see Chapter 86, Section 5.4 in the *Handbook of Agricultural Economics* (Liang and Plakias 2022).

Within political science, knowledge and application of ABM has grown rapidly because the desire to study complex phenomena has increased (de Marchi and Page 2014). Muis (2010) for example, used ABM to research political party stability and change in the Netherlands, simulating how political party popularity fluctuated due to media consumption among the voter base and competition between parties. While political party competition was a dynamic system and very rarely stable, the author concluded that the results from the ABM were comparable to public opinion polls, highlighting their potential as tools to validate or predict political system events.

In epidemiology, scholars have adopted ABM to model patterns of disease outbreak because outbreaks are complex phenomena and are difficult to predict (Miksch et al. 2019). The COVID-19 pandemic, for example, relied heavily on models to forecast trends and assist with resource management, both of which were crucial for policymakers and health agencies. The COVID-19 Agent-Based Simulator (Covasim) was created to assist policymakers and health agencies to effectively manage the crisis, and it was quickly put to use globally (Kerr et al. 2021). An agent-based approach was selected over other modeling systems to best capture the microscale complexities that are necessary for proper mitigation of the pandemic. Being able to run scenarios that test out different policy responses was noted as being immensely valuable. Several other studies introduced similar scoping models to simulate the COVID-19 pandemic (Cuevas 2020; Silva et al. 2020; Shamil et al. 2021).

Within the emerging field of sustainability science, ABM is seen as a great tool for stakeholders and policymakers to improve system sustainability by exploring and testing the effects of different scenarios. Several studies within the last decade have used ABM to discover how proposed interventions could affect food and agricultural systems related to food security, or the interactions between biophysical/climate conditions, supply chain, transportation systems, and spill-over effects from agricultural output (Liang and Plakias 2022).

3 Methods. Choosing the Appropriate ABM Toolkit

Several toolkits exist to design and run ABM. Abar et al. (2017) created an extensive list of 85 different toolkits to create ABM, where each toolkit was briefly described based on its unique properties. Due to the vast number of toolkits available, selecting an appropriate toolkit is essential and often one of the first steps in designing an ABM. ABM toolkits are quite diverse. They range in several functionalities such as: the source code, coding language, type of interfaces available, preferred operating system (OS), necessary experience with coding (novice, intermediate, or expert), modeling strength and capacity for complexity, capacity for 2D or 3D visualization, and typical domain of applications. Additionally, not all ABM toolkits are easily accessible. While many programs are open source and free to download, many need a license and are proprietary.

Five of the most commonly used ABM toolkits are NetLogo, AnyLogic, Repast, MASON, and Swarm. For this project, NetLogo (an open source package) was selected as the ABM toolkit because of its (1) relative ease of use, (2) strong source of educational tools, documentation, and tutorials, (3) free and open source availability, and (4) ability to run on all platforms and operating systems. Developed by Uri Wilensky in 1999, NetLogo is both an agent-based programming language and modeling

environment. The program provides modelers with the tools to "give instructions to hundreds or thousands of "agents" all operating independently. This makes it possible to explore the connection between the micro-level behavior of individuals and the macro-level patterns that emerge from their interaction (Wilenski 1999). It was designed to model the complexities of both natural and social systems, and was built in mind for educational and research purposes (Tisue and Wilensky 2004). The creators of the toolkit hoped to create a modeling program that would be capable of running complex simulations, but should be simple enough for students and non-programmers to make use of and create their own sophisticated models. Several computer science and modeling classes have been taught at universities that use NetLogo. The creators have documented that NetLogo has been downloaded tens of thousands of times, and find the discussion group online to be active with group members sharing ideas and advice (Wilenski 1999).

3.1 What Is NetLogo?

NetLogo has three interfaces for the user to interact with. The *first interface* is the programming environment to write and edit NetLogo code. The *second interface* is the visualization environment, where the user can see how agents are interacting and see how relevant metrics and statistics change as the model runs. Also, in this interface, the user can manually toggle model parameters through means of sliders and input buttons (features of the programming) that link back to the NetLogo code. The *third interface* is the documentation environment, where users are encouraged to document the background information about the model as well as step-by-step information for running the model correctly. In NetLogo, the agents can be used to represent any conceivable entity, such as airline passengers, cars, solar panels, molecules, buyers, sellers, batteries, etc. The environment that the agents inhabit is referred to as *a network of patches*. Patches can be used to represent any environmental entity, such as farmland, a street network, a grocery store, a microscopic cell, etc. See Figure 2 for labels of each of these interfaces within the NetLogo environment.

3.2 Applications of NetLogo

NetLogo has been a key research tool in many studies, ranging from applications in biology, logistics, economics, and sustainability. For example, it has been the selected toolkit for modeling green transportation potential in cities. Emergence of systems thinking in urban studies has integrated the food-energy-water nexus within urban agriculture networks, prompting a methodology to simulate how this integration is sensitive toward policy changes to enhance efforts toward green transportation. ABM was used to help understand this coupled system by locating food desserts and deficiencies within green transportation efforts (Elkamel et al. 2023). Gebrehiwot et al. (2022) applied the ABM approach to simulate factors influencing grower (farmer)–buyer (household) decisions while considering fresh food availability and farmland transitions to alleviate food desert challenges (Gebrehiwot et al. 2022). In these studies, the agents were individual farmers or households, green transport variables (energy capacity, mileage, and electric charger type), urban agriculture microgrid variables (technologies including solar panels and wind turbines), other urban grid facilities like stormwater treatment plants and public utilities, and farmland.

Putting these agents into an ABM structure and seeing the resulting dynamics when implementing scenarios commonly associated with public policies, such as increasing renewable energy or inflating food costs, revealed the underlying complexities of coupled systems in an urban agriculture content. Under some scenarios, household income increased and food security decreased, suggesting a relationship between the scenarios introduced and food security levels across the modeling environment. The authors found that these methods could be used to assess sustainability strategies by simulating anticipated effects of new policy or technology (Gebrehiwot et al. 2022). Because ABM relies

on local data and local knowledge, results from ABM that are context specific are not always interpretable, scalable, or generalizable (Sun et al. 2016).

Kowalska-Pyzalska (2017) used NetLogo to study sustainable development by modeling consumer willingness to pay for green energy. Consumer agents are first assigned a variable of their valuation of renewable energy, called a reservation price, and then assigned a variable of their willingness to adopt renewable energy practices, called an adoption threshold. Agents with a greater reservation price than the adoption threshold are considered potential adopters of renewable energy due to their greater willingness to pay and change their behavior toward favoring adoption of renewable energy practices. Because some of the variables are dynamic and can be specified by the modeler as parameters within the model change, different scenarios were applied to see how the population can best be incentivized to determine those that result in the greatest adoption rates. The study found that external incentives, such as financial support for adoption, offered positive outcomes to increase consumers' support for renewable energy projects.

Delcea, Cotfas, and Paun (2018) explored several scenarios within NetLogo to model the most efficient strategies to increase turnaround time among commercial aircraft by seeking different methods of loading and unloading passengers. Twenty-four different boarding patterns, such as random open seating, seat assignment by group, and seat assignment by seat, were all compared to see which pattern had the quickest flow and movement of agents. Agents were given variables related to speed, seat location, and how much luggage they carried on. For full flights, the model showed that the "by-row-back-to-front" method was the quickest, which could be helpful for airlines to adjust turnaround times and reduce conflicts.

NetLogo has been applied in studying cell biology, such as modeling of interactions between the sensory system of an organism and its surrounding environment. Dalle Nogare and Chitnis (2020) explored how the cells of a zebrafish could be influenced by its environment to modify its organ systems and biological development. NetLogo was chosen to study this phenomenon because of its visualization capabilities, as well as the relative difficulty to study such phenomena in a wet laboratory setting. This relative advantage also allows for study in biomedical research to understand complex biological systems and to investigate new hypotheses for research and development, such as the immune system (Chiacchio et al. 2014).

4. A Demonstration of Using NetLogo to Simulate Producer-Buyer Interactions within an ABM Concept

The following section elaborates how to design and create an ABM using NetLogo to analyze how *poultry producers and buyers* interact, including (1) ways to define various entities or agents, (2) ways agents interact among the patches, and (3) methods to explore complex themes such as positive and negative feedback loops, network dynamics, population dynamics, market dynamics, optimization, and self-organization. The rationale for choosing the poultry market is due to the nature of this project as a component of a large collaboration funded by the U.S. Department of Agriculture (USDA) Sustainable Agriculture Systems, focusing on an integrated system approach to examine the poultry industry from production to consumption, while taking account of environmental impacts.

To ensure the readers understand how we identify actors, factors, scenarios, and interactions in the examples described in the sections below, we need to set the stage by providing some background information about the poultry industry in the United States. The poultry industry in the United States has grown into a $77 billion industry (U.S. Department of Agriculture, National Agriculture Statistics Service 2022). Broilers made up 65 percent of the total poultry industry production, while eggs made up 25 percent and turkeys made up 10 percent. Consumption of chicken per capita has increased significantly from 2000 (76 pounds) to 2022 (99 pounds) partly due to health recommendations and cheaper prices when compared with red meat (U.S. Department of Agriculture, Economic Research

Service 2022). Improved efficiency of feeding and poultry supply chain mechanisms have boosted the prosperity of poultry operations over the years, as well (U.S. Department of Agriculture, Economic Research Service 2022).

Despite the prosperity of the U.S. poultry industry, there remains ongoing challenges. For example, Highly Pathogenic Avian Influenza (HPAI) has increased restrictions on production and exports, which threatens to raise prices and decrease demand in several markets (Chai et al. 2017; Choe 2023). Clostridium perfringens and salmonella enterica were identified as the most common pathogens, both of which are still impacting public health (Velasquez et al. 2018). Issues within the conventional poultry industry have spurred new methods toward poultry production and marketing. Supermarkets are increasingly promoting antibiotic-free and organic products due to higher demand. Organic production of broilers has continued to rise, with the value of organic broilers sold being 1.51 billion, a jump of 35 percent from 2020 (U.S. Department of Agriculture, National Agriculture Statistics Service 2023). On the consumer side, demand for organic, fresh, free-range, and antibiotic-free products is growing (Vander Mey 2004; Martínez Michel, Punter, and Wismer 2011; Van Loo et al. 2011). Increased demand leads to increased production of these products, allowing prices to be more affordable for the average consumer (Adamski, Kuzniacka, and Milczewska 2017; Schipmann-Schwarze and Hamm 2020).

4.1 Learning Model for ABM Applications

We will begin with a model with two different sets of agents—buyers and sellers—and explore how they interact in a poultry market. This is a simplified case study that proposes a methodology to use NetLogo for simulating market dynamics within an ABM analysis. *Buyer agents* are consumers who can make decisions whether to pay a premium for specific types of products, such as organic or pasture-raised chicken meat. *Seller agents* represent different scales of farms, such as a typical large farm that offers cheaper products and at greater quantities, or a typical small farm that offer products at a premium price with attributes that are appealing to a certain demographic of buyers.

4.2 Classroom Activity: Getting Started Learning NetLogo by Completing Tutorials

Upon selecting an appropriate ABM toolkit, the first step is to seek out which educational resources are available. For use in the classroom, we recommend priming students by directing them to the NetLogo website and having them complete the provided tutorials. The NetLogo website (https://ccl.northwestern.edu/netlogo/) features many resources to help a new user, including links to tutorials, dictionaries, and videos (Figure 1 below). The website provides clear instructions on how to download NetLogo, or if preferred, use the NetLogo Web application, which does not require any installation. Once downloaded, three key tutorials are worth exploring. *The first tutorial* introduces the user to the model's library, a set of several pre-made models that the user can experiment with, without having to create any code. This introduces how to control the parameters of the selected model by reviewing how different interface elements interact with the model, as well as actually running the model under different parameters.

The second tutorial focuses more on editing models as opposed to simply observing them. This is done through introducing commands and reviewing how commands can alter the model's properties. For example, the command center is where the user can change the color of an agent, such as changing the color of a house from red to blue. *The third tutorial* teaches the user how to start building a model from the beginning. The example given is how to build an ecosystem, where turtles roam around the environment and eat grass, represented by patches, which in turn provides the turtles with energy to further roam.

For further information, the programming guide and interface guide are both lengthy documents that describe the functions possible within the ABM toolkit. The *NetLogo Dictionary* provides definitions for each of the hundreds of primitives that exist as foundational language elements of the NetLogo

Figure 1: NetLogo webpage (https://ccl.northwestern.edu/netlogo/), which houses download instructions, as well as a host of learning resources and contact information.

programming language. All of these resources can be found on the ribbon on the left of the NetLogo website. If assistance is required when working through development of a model, the *NetLogo User's Group* (https://groups.google.com/g/netlogo-users?pli=1) is an active community where members may pose their questions and receive valuable feedback from other members.

4.3 Creating a Buyer-Seller Model for the Poultry Industry: Step by Step Instructions and Notes

In the poultry industry, there are several important actors. Within an ABM schema, each set of actors will be represented by a set of agents. A schema is the logical and organizational structure of a model. Create an initial schema for the project by considering all the agents necessary. This schema will be tied to the end goal of the project. In our case, it is to create a simulation of the poultry industry to test out different scenarios and find potential pathways for increased sustainability within the industry.

Step 1: Conceptualize Agents by Assigning Definitions and Assumptions

The following types of agents would be considered in a complete poultry industry model:

1. Farmers and farm workers.
2. Consumers—both direct consumers that buy meat to consume, but also intermediate consumers that purchase by-products of chicken for use in other things, such as animal feed or fertilizer.

3. Processors—butchers, inspectors, packaging, labeling, transportation to market, and other actors within the supply chain.
4. Agencies—USDA, Food and Drug Administration, Centers for Disease Control and Prevention, etc.
5. Chickens—How they interact with each other and maintain a healthy lifestyle.
6. Environment—Including variables of environmental health mostly at the farm level, but also including environmental impacts of waste and transportation.

For the purposes of this initial simplified model demonstration, only two agents will be selected—farmers and consumers.

Step 2: Identify Interactions Between Agents at the Most Fundamental Level

For initial model development, start simple and expand rather than introducing all possible agents into the model. First, pick two agents that interact at the most fundamental level. *Begin with one farmer (seller) and one consumer (buyer).* The simplest interaction is if the buyer decides to make a purchase from the seller. In this case, the decision a buyer makes is to either buy the seller's product or not. *At the least complex level, there are no clear assumptions that the modeler needs to make*. Writing the code to model this transaction requires adding relevant variables, such as assigning the seller an amount of price they are willing to sell their product for and assigning the buyer an amount of money they are willing to buy the same product for. In this case, a simple logical operator can establish the link between each agent's variable and determine if there is a successful purchase. If the buyer's amount they will spend is greater than the seller's amount they will sell for, then a purchase or transaction can be made. If the opposite is true, a purchase will not be made. Figure 2 below shows this simple dynamic, where one triangle is representing the buyer and the other represents the seller. The buyer is willing to spend $10 and the seller is willing to sell for $5; therefore a successful transaction occurs, represented by the yellow line between them. If the buyer is willing to spend $5 and the seller is willing to sell for $10, there will be no transaction and no yellow line will appear.

Step 3: Increase the Number of Buyers, Sellers, and Behaviors That Drive Market Exchanges

Two sellers and one buyer will be introduced in this step of the poultry market interaction model. The first seller, Seller A, represents a large commercial producer. Seller B represents a small local farm. Seller A and B can be distinguished by many characteristics, such as the number of birds they have sold, the total pounds they have sold, their gross earnings per year, their market channel and methods for selling products, their keywords and company mission, and their target demographics of consumers they sell to. In the earliest iterations of the model, the sole separating feature between the sellers is their selling price.

The model, shown in Figure 3 below, now has two sellers, which are represented by the blue and green bodies. The buyer, now represented by the orange smiley face, has the option of buying from either seller. At this second level of complexity in the model, the assumption is that the buyer will purchase only one product from the seller who is selling at the cheapest price if the seller's selling price is less than what the buyer is willing to pay. The yellow link between the buyer and the green seller indicates a successful purchase, while the blue link between the buyer and blue seller indicates that there is no purchase. As the model develops, there are now more interface elements and visual plots and windows. The turquois buttons in Figure 3 allows the user to change behaviors of the buyers and sellers, as well as determine the total amount of money the buyer has available to spend. The large plots on the right track the seller's prices they will sell at and the buyer's price they will pay, which will change after every tick. These will also update after every tick (A tick is the discrete time component of a NetLogo model). Each tick, in this case, represents a new

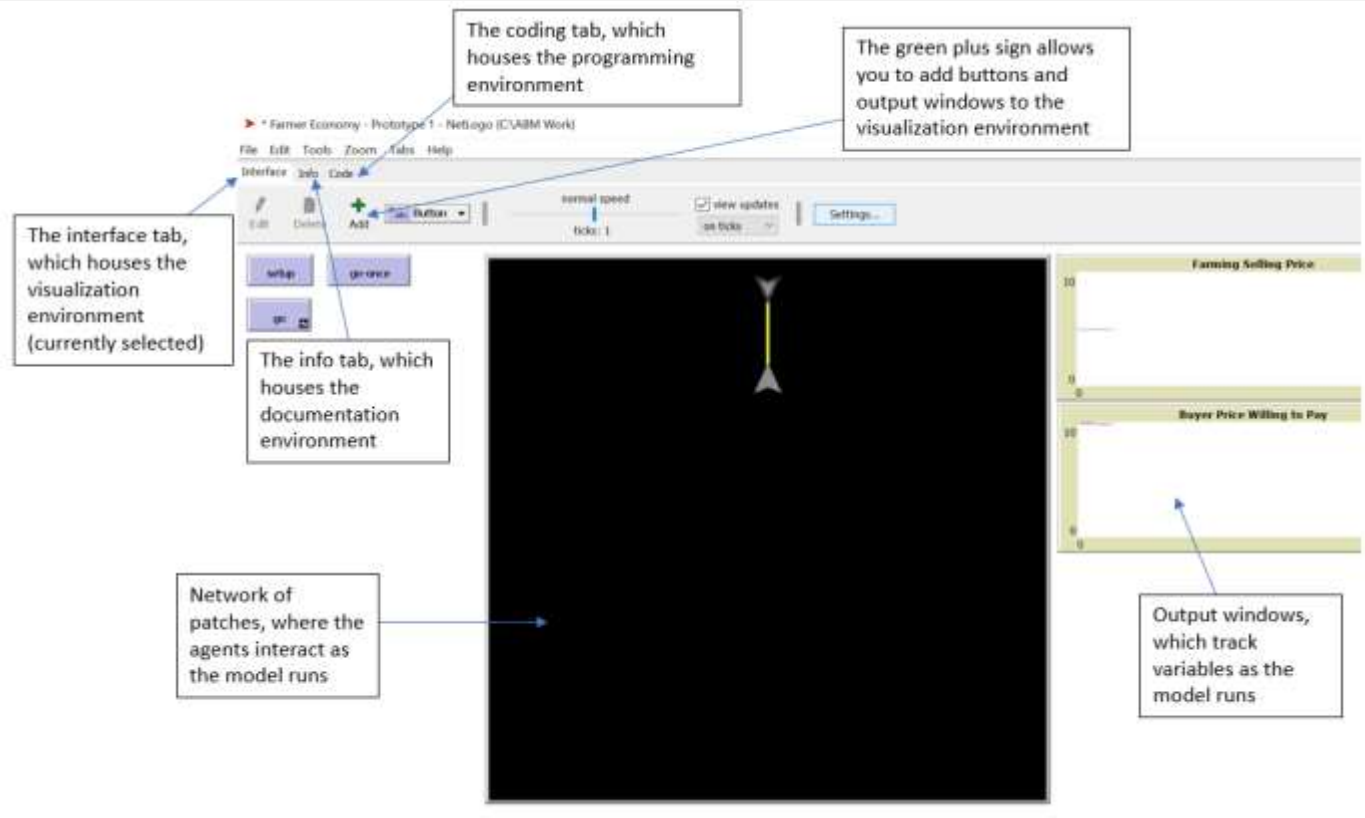


Figure 2: Screenshot of the model in development at its first level of complexity, showcasing the interactions between one buyer and one seller. Labels indicate several of the critical interfaces within the NetLogo environment.

opportunity for a buyer to interact with a seller and potentially make a purchase. In this scenario, a tick can be thought of as each time a buyer goes to the market to buy a product. So, the first tick can represent the first time a buyer goes to market, the second tick is the second time they go to the market, etc. Also included now are windows showing how much money the buyer has left, how many items have been bought, the average sale price, and number of products remaining.

All of NetLogo's buttons, sliders, monitors, and output windows, as seen in Figure 3, need to be manually added by clicking on the green "add" button in the top left corner of the program. Once the desired window is added, it needs to be specified and referenced in the code in order to know which variable the window is synchronized with. Each window can be edited by right-clicking and changing the settings. This is where the variable(s) will be selected and where other settings can be changed, such as the range of values for a sliders button, or the colors of a graph, or the graph's axis parameters.

It is relatively easy to increase the number of buyers or sellers in NetLogo, as the user simply has to increase the population (such as in the code, changing from population of 1 to population of 10). The difficulty lies with assigning each new agent its own unique characteristics. If the user were to simply change the buyer population from 1 to 5, they would all be clones who have the same characteristics, such as having the same willingness to pay value, same starting budget, same attribute preferences, etc. Figure 4 shows the same model now with 3 sellers and 20 buyers. However, if all 20 buyers are clones, there is little value in running the model with 1 buyer or 20 buyers. The assumptions remain true at this level of complexity in the model, where buyers will only purchase from the cheapest seller, if the seller's products are below the buyer's price range.

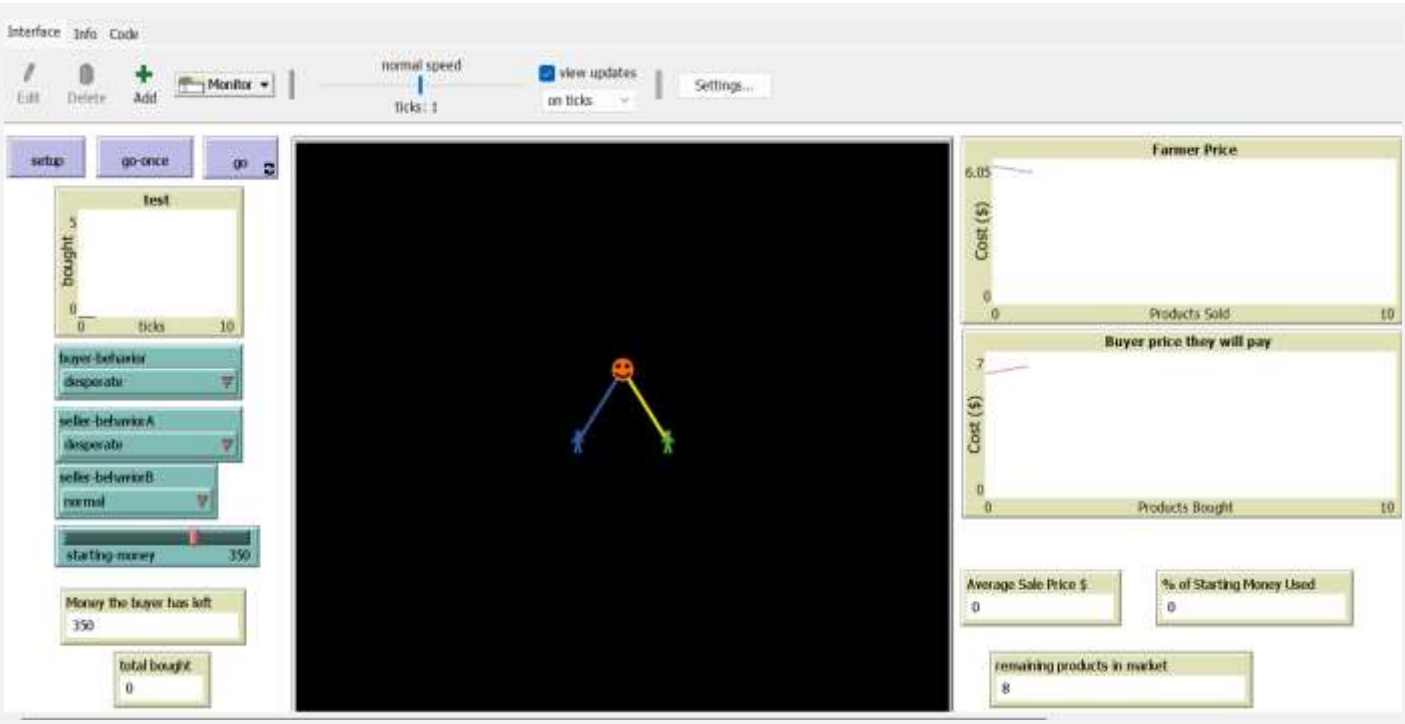


Figure 3: Screenshot of the model in development at its second level of complexity, where one buyer is now interacting with multiple sellers.

The solution to having buyers that are clones of each other is to make use of a CSV data file extension created in Microsoft Excel (Figure 5), which allows for the user to directly specify the traits of each buyer agent (willing to pay, amount they want to buy, preference for attributes, etc.). Each column

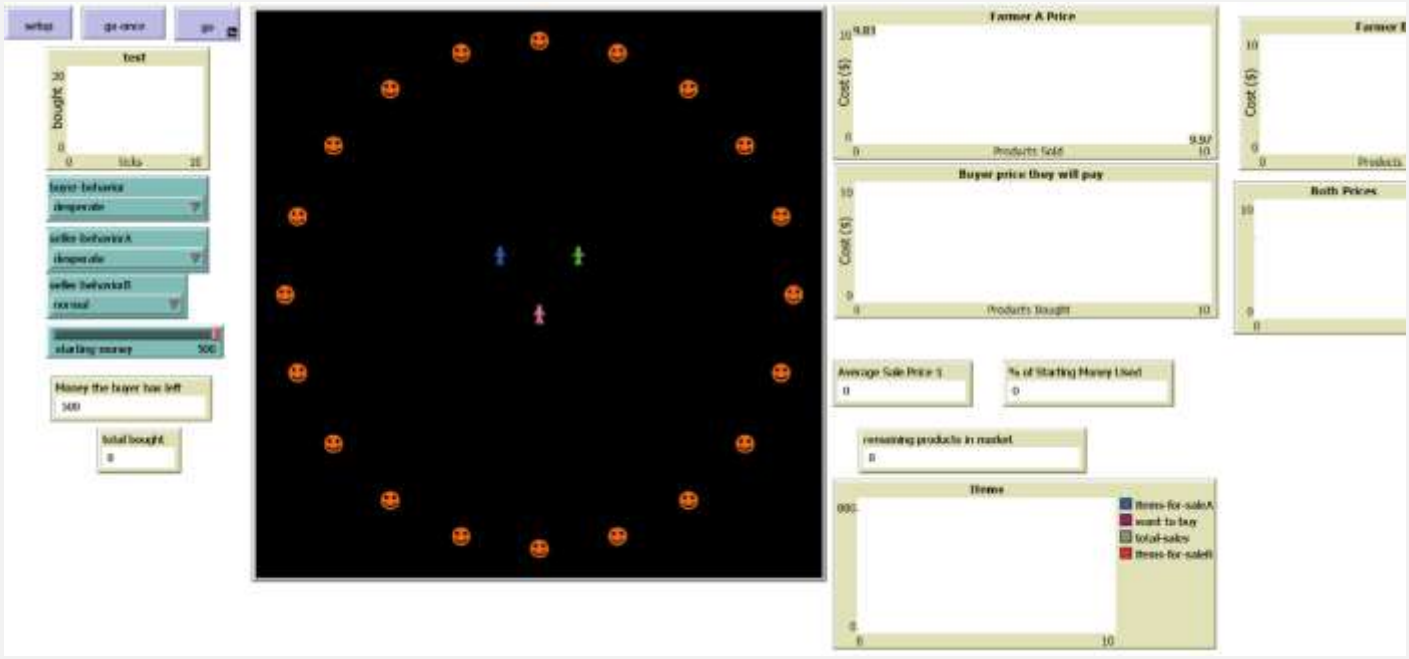
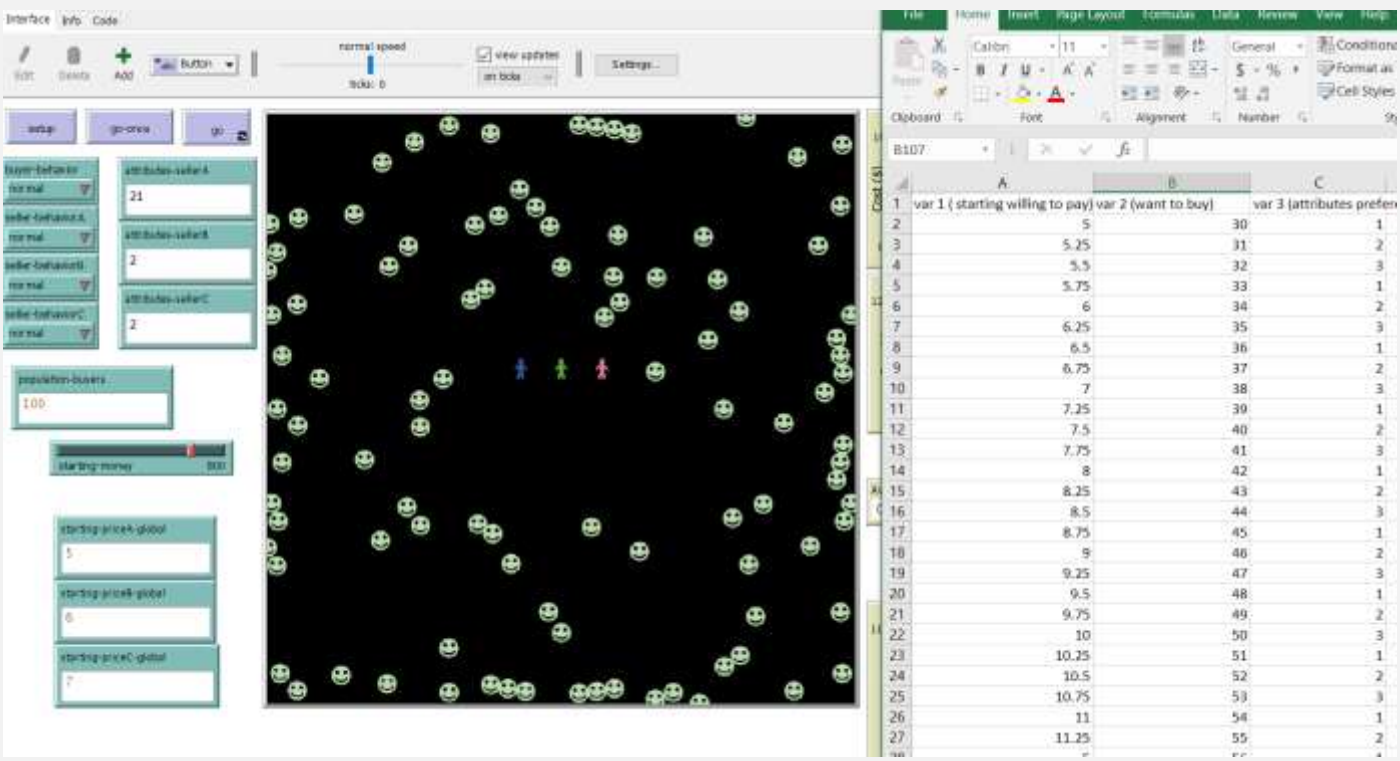


Figure 4: Screenshot of the model in development at its third level of complexity, where multiple buyers are interacting with multiple sellers. In this screenshot, all of the buyer agents are exactly the same.



	var 1 (starting willing to pay)	var 2 (want to buy)	var 3 (attributes prefer
2	5	30	1
3	5.25	31	2
4	5.5	32	3
5	5.75	33	1
6	6	34	2
7	6.25	35	3
8	6.5	36	1
9	6.75	37	2
10	7	38	3
11	7.25	39	1
12	7.5	40	2
13	7.75	41	3
14	8	42	1
15	8.25	43	2
16	8.5	44	3
17	8.75	45	1
18	9	46	2
19	9.25	47	3
20	9.5	48	1
21	9.75	49	2
22	10	50	3
23	10.25	51	1
24	10.5	52	2
25	10.75	53	3
26	11	54	1
27	11.25	55	2

Figure 5: Screenshot of the model in development at its third level of complexity, where multiple buyers are interacting with multiple sellers; however, unlike in Figure 4, all of the buyers are unique based on the attributes shown in the CSV data spreadsheet shown. Variables for each buyer include their willing to pay value, number of items they want to buy, and product attribute preference.

in the Excel table represents a trait. Each row represents one individual. Figure 5 shows the environment with 3 sellers and 100 buyer agents and the spreadsheet that holds their characteristics. The data is currently made up, but later on in the process, the data will be corrected to reflect real-world buyer characteristics.

While a large percent of the population solely makes purchasing decisions based on price, several make their decisions on other factors such as targeting desirable attributes in the product they are seeking. Implementing levels to the buyer decision-making process increases realism. While not introduced in this example, other decision rules can be assigned to agents. One example is specifying agent behavior based on probabilities. Giving individual probabilities to agents can further mirror how irrational agents interact with their space. Within the context of this buyer-seller marketplace simulation, a simple example for probability-based behavior could be that 50 percent of the time a buyer goes to market, they prefer products based on their attribute, and 50 percent of the time they prefer products solely based on price. Bonabeau (2002) further discusses individual probabilities for use in simulating human systems.

4.4 Order of Operations

The order in which buyers engage with sellers is important to note when interpreting the results of the model. Consider when there is only one buyer, such as introduced in the initial steps of model development. Each tick represents one time the buyer goes to market, and each time they go to market, the variables are the same as when they had left the tick prior. However, when multiple sellers are

engaging with multiple buyers, the order of operations becomes necessary to understand. For each tick, each buyer interacts with each seller to determine if a purchase will be made. Using the example in Figure 4, the first engagement starts with Buyer 1 deciding what to buy from Sellers A, B, or C. After this engagement, Buyer 2 repeats this process, followed by Buyer 3, etc., until all buyers have gone to market to engage with the sellers. Once this happens, the next tick commences and the process repeats. This means that the opportunities presented to each buyer are not completely equal. We will return to this point when we increase the complexity of the model to discuss what this order of operations conceptualization means for interpreting results.

4.5 How to Modify Preferences for the Agents

Figure 6 displays the difference in how buyer preferences can affect the market economy. If we have one buyer who prefers a specific attribute, say attribute "1" (e.g., organic, pasture-raised, etc.), and a farmer is selling a product with that attribute, the buyer will buy that product and disregard any of the other sellers' product, even if other sellers are selling products at prices that the buyer is willing to pay. It is only if there are no products with matching attributes that the buyer seeks will the buyer then only buy products that are cheaper than they are willing to pay. Just as in real life, not every buyer will have the same preferences for products, or even have any preference at all. In this case, they are likely to choose

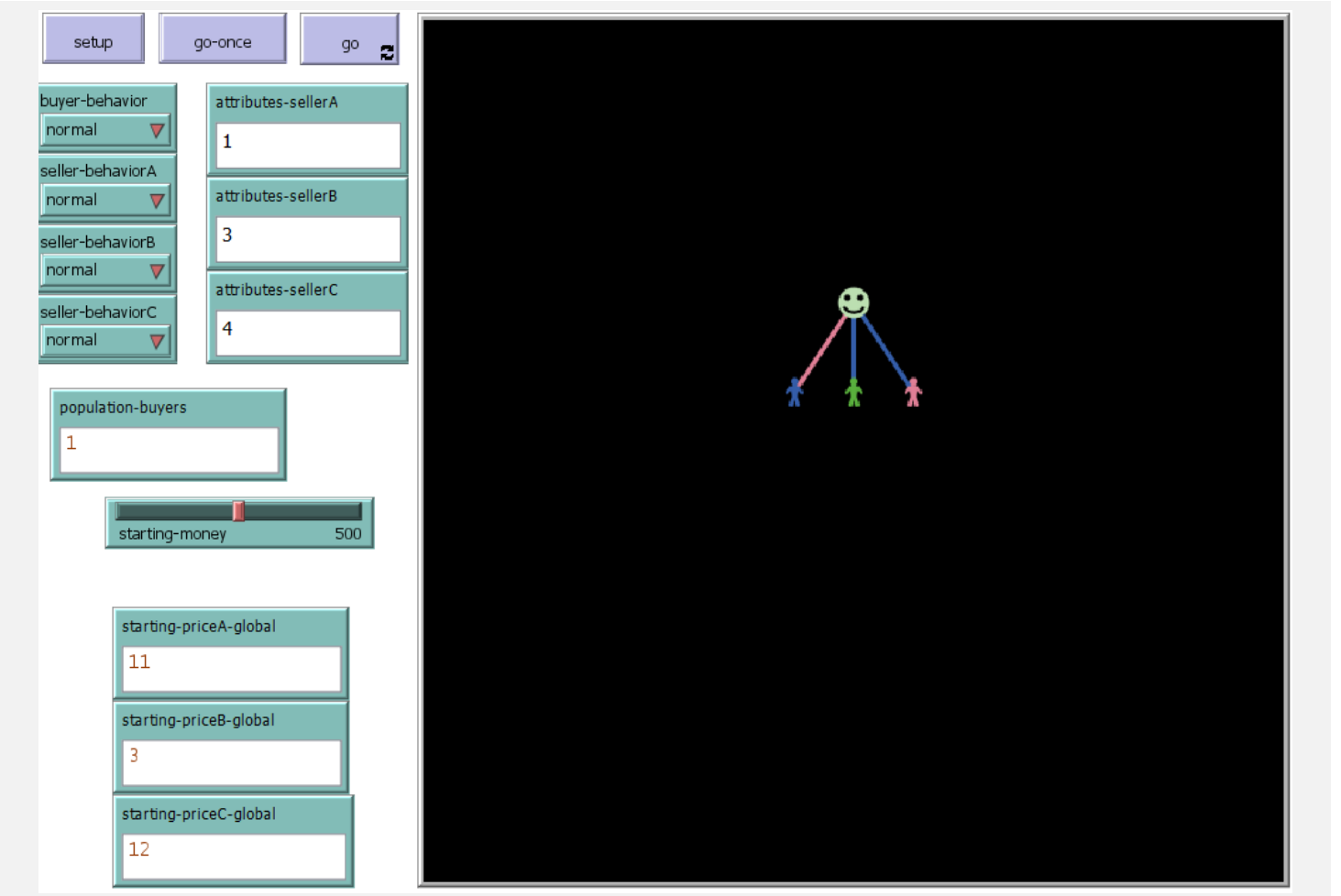


Figure 6: Screenshot of the model in development at its fourth level of complexity, where buyers need to choose between buying products with attributes they desire or buying the cheapest products. In this example, because Seller A has attributes the buyer desires, the buyer buys from Seller A despite cheaper options on the market.

the cheapest option.

In Figure 6, a pink line indicates a purchase made on behalf of matching attributes between buyer and seller (see how the green input element "attributes-Seller A" is "1," which matches the buyer's preference for attributes coded as "1"). So even though the middle seller is selling their product cheaply, the buyer still only buys from the seller on the left. In Figure 7, the attributes of the left seller have changed (it is now "2" instead of "1"), so the buyer does not have any choices on the market for attributes they desire. In this case, they will only purchase from the middle seller because they have the best price point, which the buyer is willing to pay. The yellow indicates this purchase. Now that buyers must consider attributes, an extra level of complexity is added that requires the modeler to make new assumptions. In this case, buyers will first decide who to buy from based on attribute preferences. If no attributes available in the marketplace match what the buyer prefers, the buyer will default to purchasing from the cheapest seller, as was the assumption in earlier stages of the model.

Step 4: Slowly Add Complexity and Realism to the Model by Connecting Variables and Assigning Agent Behavior Based on Empirical Studies

Adding other variables to this relationship can add realism, such as by assigning a number of items that the seller owns. For example, each time there is a successful transaction, the seller will own one less

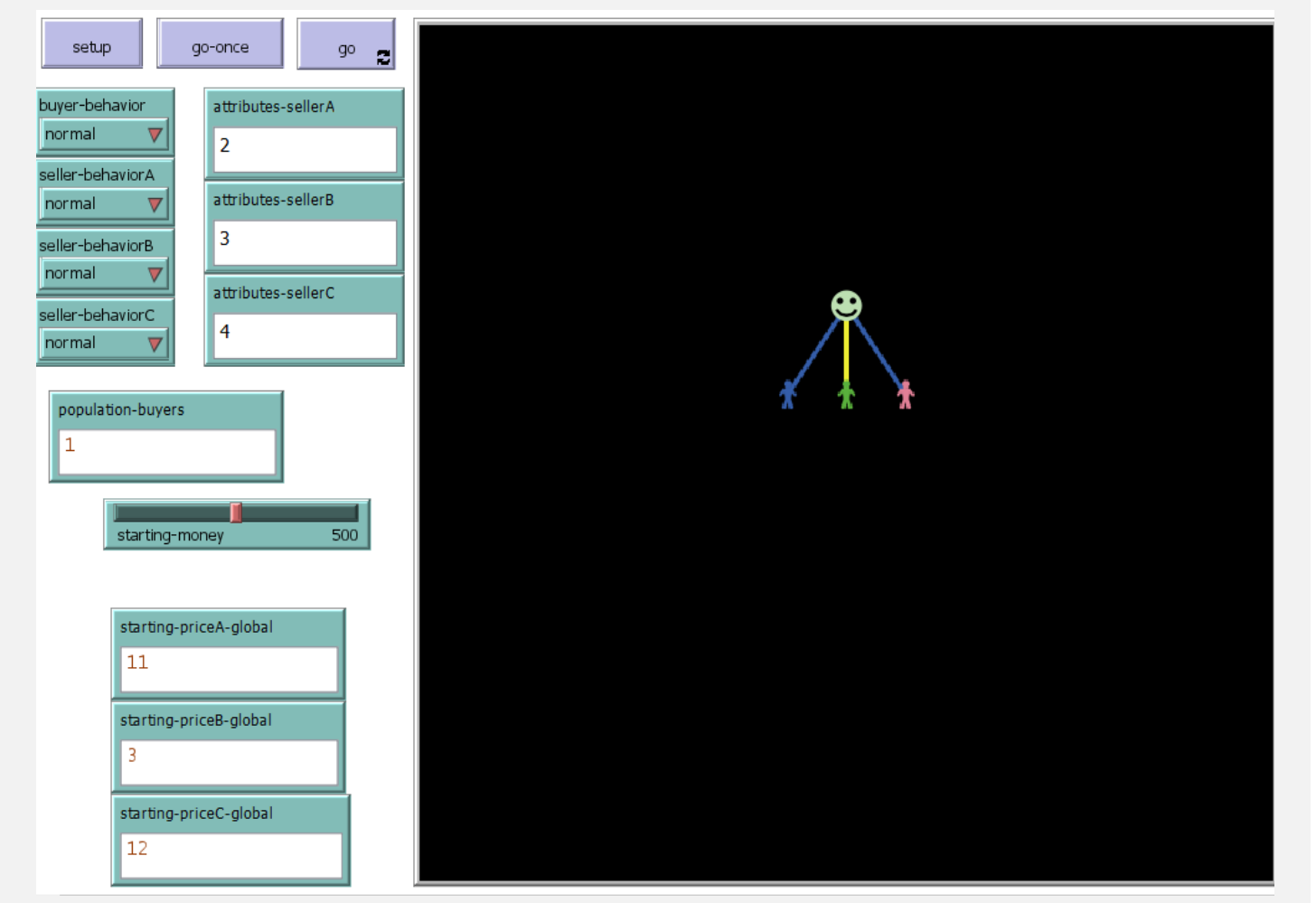


Figure 7: Screenshot of the model in development at its fourth level of complexity, where buyers need to choose between buying products with attributes they desire or buying the cheapest products. In this example, because no seller has attributes the buyer desires, the buyer buys from Seller B because they have the cheapest product available.

item. If the seller has no more items to sell, no more transactions can be made. Consider how the order of operations of how buyers and sellers interact may impact this in a scenario with multiple buyers. If there is one seller that has only three items of one product and both buyers want to buy it during each trip to the marketplace (tick), Buyer 1 will buy the first item, and Buyer 2 will buy the second during the first tick, and Buyer 1 will buy the third item during the second tick. This leaves Buyer 2 without the option of buying that product because it is sold out. So, the modeler needs to be careful when interpreting these results, as in this case it would be a mistake to assume that Buyer 1 had greater ambition than Buyer 2 to buy the products because at the end of the model run, they had purchased more of that product.

Once more than one buyer and seller agent are introduced, the user must start to make certain assumptions about how the two sets of agents interact. For example, because several studies on consumer behavior find that cost is the first determinant for consumers deciding what product to buy, one assumption is if there is one buyer and multiple sellers that sell the same item, the buyer will purchase from the seller who is selling their item at the cheapest price. However, more assumptions must be made if there are several factors at play for when a consumer is deciding. For example, if a seller is selling products with a specific attribute, such as if it is certified organic, how does that compare to another seller's product that is cheaper, but not certified organic? These are the questions a modeler must think about throughout the duration of model development.

Several studies exist that demonstrate behavior of consumers and producers that can be referenced when assigning behaviors to the model's agents. Consumer surveys demonstrate that consumers are often willing to pay a premium for poultry products with desirable traits, such as if it is labeled organic or has other ethical production claims (antibiotic free, free range, pasture-raised, etc.). Several variables determine these consumer behaviors, such as gender and age, or income levels (Fatha and Ayoubi 2023; Mohammadi, Saghaian, and Boccia 2023). Education level and awareness of ethical food production also contributes to a consumer's willingness to pay premiums for poultry with enhanced labeling (Kamphuis, Bekker-Grob, and van Lenthe 2015; Karavolias et al. 2018). Van Loo et al. (2011) determined that consumers seeking general organic poultry breast were willing to pay a 35 percent premium above the conventional breast price, and those seeking USDA-certified organic poultry breast were willing to pay a 103 percent premium. Lai and Yue (2020) compiled a list of more than twenty similar scoping studies that measured consumers' willingness to pay a premium for products labeled organic, covering foods such as fruits, dairy, and salty snacks.

One final example implemented in the model to add complexity is assigning generalized behaviors to both buyers and sellers. Buyers can be assigned to have a buyer behavior of normal, desperate, random, or a mix. Normal behavior means that the buyer does not change their willingness to pay after each transaction opportunity. Desperate behavior means that the buyer's willingness to pay increases after each tick in the model, with the willingness to pay increasing even more when there is not a successful purchase. So, in this model's iteration, if a buyer is willing to pay $5 but does not buy anything, the next round they will be willing to pay 5 percent more than the $5 they were willing to pay previously, indicating a sense of "desperation" in their behavior. Random behavior means that after each round, the buyer's willingness to pay will fluctuate from being willing to pay 10 percent more to 10 percent less than their previous offer. This behavior mirrors the sporadic nature of a consumer as time passes. A mix behavior means that the buyer's behavior may be either normal, desperate, or random. The seller's behavior options operate in the same way, where a seller set to desperate will lower their asking price each time they do not successfully sell one of their items.

The ability to toggle consumer behavior in this manner can offer more possibilities to explore dynamic consumer behavior. For example, much literature put forward about consumer behavior during the COVID-19 pandemic demonstrated the reactionary and occasionally unpredictable nature of consumer buying habits, forcing producers to adapt as well. For example, several studies noted that a perceived scarcity in product availability increased consumer demand, influencing both consumers'

willing to pay and producers' willing to sell levels (Laato et al. 2020; Pantano et al. 2020). Four key factors are always shaping consumer habits. The factors are the current dominant social context, emerging technology, new rules and regulations surrounding shopping, and unpredictable events such as the COVID-19 pandemic (Eger et al. 2021). Assigning dynamic behaviors to buyer and seller agents allows for more flexibility in running scenarios that can mirror real-world marketplaces, such as consumer stockpiling phenomena, which occurred during the COVID-19 pandemic. It is possible to create different populations of buyers each with their own assigned unique behaviors, but that is outside of the scope of this introductory demonstration.

4.6 Notes on Model Theory and If the Model Is Deterministic vs. Stochastic

Rules assigned to agents that drive agents' behavior mirror that of a hierarchical decision tree model. Agents are given sets of scenarios, and then the rules given to them decide how they act. For example, the first stage of interaction between buyer and seller in Scenario 2 (further elaborated below) kickstarts a series of true/false tests to determine the next course of action in the model. The flow of these tests can be generally summarized as follows.

1. Does Buyer A's preference for a specific product attribute match what Seller A is selling? If true, a purchase is made. If false, the test repeats between Buyer A and Seller B. If Buyer A finds no matches with any of the sellers based on product attribute, the next test proceeds based on price.
2. Is Buyer A's willingness to pay value greater than Seller A's willingness to sell value? If true, a purchase is made. If false, the test repeats between Buyer A and Seller B. If Buyer A makes no purchases with any sellers, the tick ends for that buyer. The agent will repeat the process when the next tick starts after all other buyers have gone through the decision tree.
3. If a purchase takes place, the following variables are updated; buyer money, seller money, buyer products desired, seller inventory, and the buyer's and seller's assigned behavior (if they are set to a behavior other than "normal"). If no purchase takes place, none of these variables are updated.

Several small caveats exist within the decision tree schema. For example, all conditions may be met for a purchase to take place (product attribute match or willing to pay value outweighs willing to sell value), but if the seller has no products left because they have all been sold, a purchase will not take place. This also occurs when the buyer has bought their desired number of items or if the buyer does not have sufficient money to make the purchase. The decision tree schema can be further explored in the code, which is made available in this manuscript in the appendix as well as through GitHub. The code is available as an open-source resource.

Each of the two scenarios presented below offer a different perspective on modeling and help illustrate the possibility of needing to run the model multiple times. The model presented in Scenario 1 is a deterministic model, where if the parameters are not changed, the model will produce the same results every time. This is because there is no randomness associated within the model's operations. NetLogo uses Java's "strict math" library, which will produce identical results no matter how many times the model is run or if the model is run on different platforms. However, this changes for Scenario 2. The assigned behaviors of the buyers and sellers in this scenario are switched to an option aside from the default setting of "normal." The coding for these alternative behaviors ("random," "desperate," and "mix") introduces random numbers to determine how much to alter the buyers' and sellers' willing to pay and sell values. This puts the model in a stochastic state, where running the model multiple times will produce different results. This requires the need to fully understand the model's parameters and how exactly randomness is integrated into the model's operations to best understand any stochastic model's results. To note, while not used in this project, the *random-seed* command may be used instead

of the *random* command in order to get the same sequence of random numbers each time the model is run, which will create scientifically reproducible results.

5. Run the Model Under Different Parameters to Explore Different Scenarios

We have set up two different scenarios to demonstrate some potential uses of the modeling framework. The first example demonstrates how buyers have a choice between buying products that are the lowest cost or instead buying products that have desirable attributes, where they are willing to pay a premium for those attributes. We run the model to see how these dynamics reflect in terms of market sales.

Scenario 1: Comparing the Value of Cheapness Versus Selling Products with Desirable Attributes

The parameters for the model are as follows: there are three sellers, each selling a different product. Seller A, representing a large-scale poultry firm, is selling conventionally raised chicken meat at $6.71 per lb., which is the break-even sales cost for North Carolina farmers selling this product in 2021 according to the North Carolina Farm School (2022) and North Carolina Cooperative Extension (n.d.). Seller B, representing a mid-size regional poultry farm, is selling non-GMO pasture-raised chicken meat at $7.30 per lb., and Seller C, representing a small-scale local poultry farm, is selling organic chicken meat at $7.76 per lb., both of which are also the break-even costs for those respective strategies.

Of 50 buyers total, 40 percent will pay the cheapest price and will not factor in product attributes at all, and 40 percent would be willing to pay 10 percent more to receive a more desirable product, in this case non-GMO pasture-raised meat. The remaining 20 percent are willing to pay a 35 percent premium to get organic products. These trait assignments are generalized from the U.S.-based consumer surveys of Vander Mey (2004) and Van Loo et al. (2011). Therefore, the first category of buyers is willing to spend $6.71 per lb., the minimum to buy conventional chicken meat in this scenario, the second category of buyers is willing to spend $7.48 per lb. for non-GMO meat as long as there is a seller with that product selling beneath that price, and the third category is willing to spend $9.06 per lb. as long as there is an organic seller selling cheaper. Buyers are assigned a random number between 5 and 20 for the number of products they wish to buy, which is designed to account for not every buyer buying products at equal intervals across time. When a buyer has bought all of the products they wish to buy, they will no longer participate in the model, indicated by their icon in the model fading to a dark grey. After every successful or non-successful purchase, both buyers and sellers will maintain a constant willing to pay and willing to sell price, so a constant purchasing behavior over ticks is employed.

Upon running the model through ten ticks, the results are presented by Figure 8. Seller A sold 192 products and had total sales of $1,288, Seller B sold 150 products and had total sales of $1,095, and Seller C sold 140 products and had total sales of $1,087. In Figure 8, these results are displayed by the output monitor buttons in the lower right-hand corner. Because in this example the generalized buyer and seller behavior is set to “normal,” the willing to pay and willing to sell values are kept static during each tick (see how the graphs in the right corner indicating these values are flat). In this case, running the model again without changing any parameters will result in the exact same results each time. We will see how this is different in the next example, which introduces dynamic agent behaviors.

Scenario 2: Analyzing Market Dynamics When Buyer and Seller Behavior Is Modified

Poultry market dynamics are constantly changing due to behavioral sensitivity of both buyers and sellers. Over time, internal and external forces may shift the willingness to pay of buyers and willingness to sell of sellers. Additionally, not all buyers will behave in the same manor when deciding on appropriate value they are willing to pay. An agent-based model can capture these adjustments. This

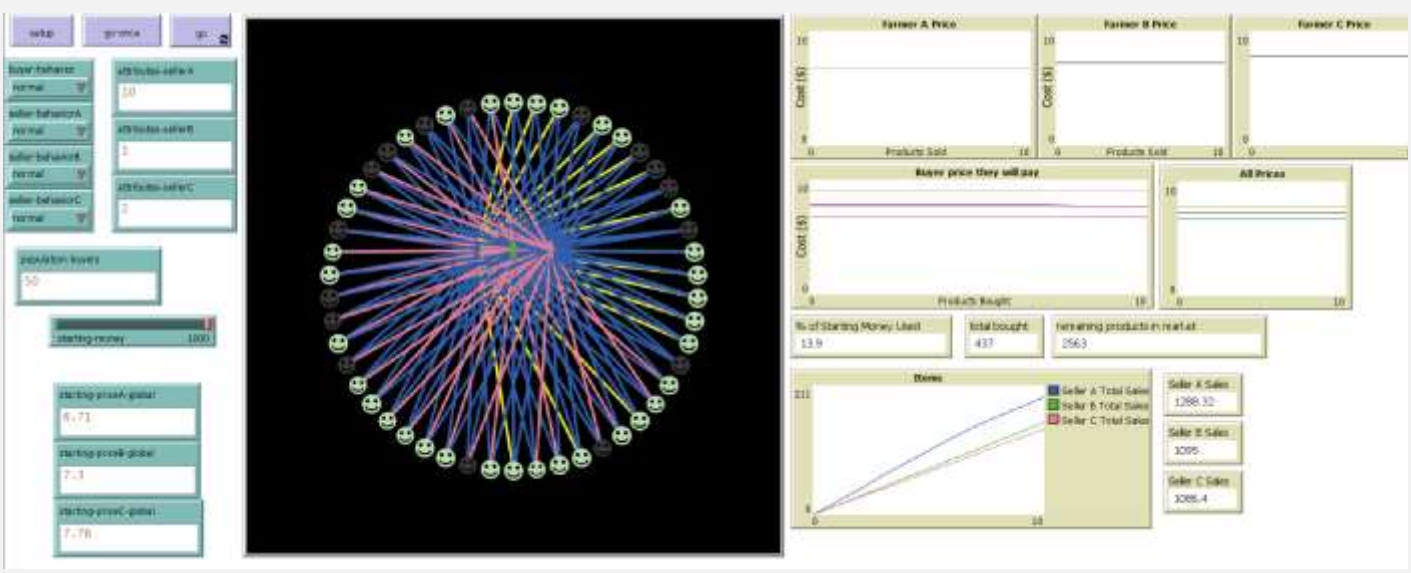


Figure 8: Screenshot of the model interface after running the first scenario.

next scenario introduces four different behavioral options, which were first discussed in Step 5 of the model development section. In this model scenario, the buyers are given a random behavior, where after each tick, their willingness to pay changes a random amount between 5 percent and -5 percent. Seller A's behavior will remain as normal, where their selling price remains constant across ticks. Seller B's behavior is set to "desperate" where with each successful purchase, their asking price will increase 1 percent, while for each unsuccessful purchase their asking price will decrease by 2 percent. This models a seller's potential behavior to further capture the market by decreasing their asking price to find the optimum price buyers will consistently pay. Seller C's behavior is set to "mix of all," which randomly assigns either a "normal," "desperate," or "random" behavior. In this model run, attribute preferences are not accounted for.

Results of the model after ten ticks are displayed in Figure 9. Seller A sold 84 products for a total sales of $584, Seller B sold 314 products for a total sales of $1,615, and Seller C sold 144 products for a total sales of $653. While Seller B had the most total sales, the desperate behavior greatly lowered the asking price of each product so the total average sale was $5.14 per lb., indicating a return below the break-even value for their product production. In Figure 9, notice how the different behaviors influence the plots for each seller's asking price and for the buyer's price they will pay. Seller A's price remained a flat line, Seller B's price trended downward as they continually lowered their price to meet demand, and Seller C's price fluctuated. The buyer's average price they will pay remained relatively constant as indicated by the middle red line. The top red line indicates the maximum amount one of the fifty buyers was willing to spend, which increased up to $11 per lb. at one point. The bottom line indicates the minimum amount the buyers were willing to spend, which dipped down to $5 per lb. near the end of the model cycle. In contrast with the first static example, if we were to run this model again without changing any parameters, the results would be different each time due to the dynamic nature of the assigned behaviors.

6. Discussion and Implication

This paper provides an overview of the definition of ABM, their applications, and some unique features to separate ABM from other types of model frameworks. More interdisciplinary and transdisciplinary studies are choosing ABM to incorporate complex interactions, decisions, outcomes, and consequences

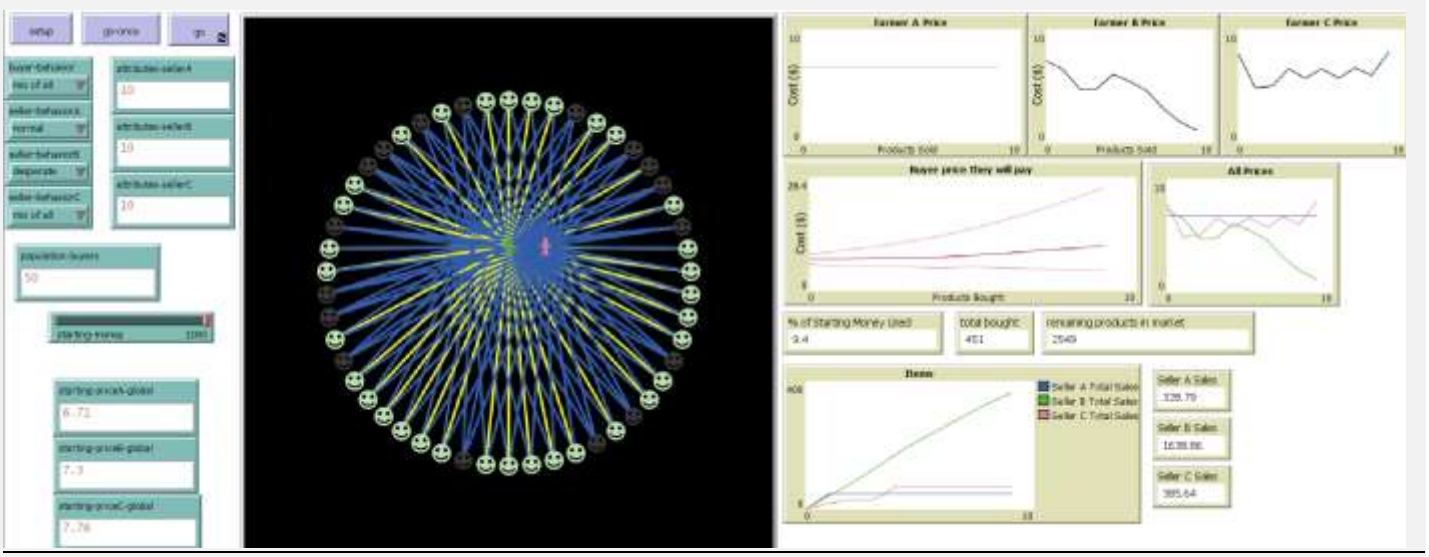


Figure 9: Screenshot of the model interface after running the second scenario.

for system analyses. The increasing popularity of ABM has gained attention across the social sciences when dealing with agri-food systems. We offered an example using NetLogo as one toolkit to construct ABM, given its user-friendly model nature and well-documented resources that are easily accessible online. However, this is only one tool, and it poses some challenges.

A first challenge upon initially starting the project is properly conceptualizing how agents interact with each other and how to make those interactions reflect in the model by manipulating the code. Essentially, it can be difficult knowing exactly how to get started. One excellent solution is to explore the model's library built into NetLogo. The model's library has pre-built models that range in application. In looking for ideas in economics, the simple bidding market model (Baker and Wilensky 2017) provides a good overview of how to write code for interactions between a buyer and seller, and also provides a starting point for understanding how to write code for changing buyer and seller behavior. Additionally, noticing the sections of code used to model transactions, namely using the links feature to demonstrate which relationships occur between agents, was a major asset for development of the poultry model.

A second challenge is scaling up from one to multiple agents. Upon having successfully created a model showing the interaction between one buyer and one seller, creating a second seller that the buyer can buy from proved complex given how much of the code needed to be edited to account for the second seller. A solution was to assign variables as global variables rather than turtle-only variables. Using global variables means those variables can be applied to several different agents at once, as opposed to just being applied to one agent. A general tip is to make small changes to your code at a time and work incrementally. Each time the code slowly improves and the model runs with positive changes, note what changes were made via comments or writing in the documentation tab.

The value in setting variables as global variables also applies for setting up dynamic plots or histograms in the interface tab to track variables as the model runs, as tracking variables can only be assigned as global variables. Making sure there is an intuitive way to see and track variables as they change as the model runs is an excellent method for interpreting the model as it is running. Along these lines, adding input buttons to the interface tab will make the model much more intuitive and user-friendly, both for the modeler as well as for any collaborators that do not have coding experience. Using input buttons and sliders allows for changing of model parameters in a more intuitive way rather than going into the programming environment. For example, if you wanted to edit how much total money exists in the simulation, a slider that allows for selecting values between 1.00 and 10,000 is easier than going into the code, navigating to the appropriate variable, and manually entering the desired value.

Last, rather than creating hundreds of new buyer agents explicitly in the code, each with their own unique properties, figuring out how to connect a CSV data file to the model and creating a loop that assigns traits to buyers from the CSV data file is invaluable in saving time and efficiency. The CSV data file extension was introduced after reaching out to the NetLogo community. After watching a brief YouTube instructional video on how to properly connect a CSV data file and learning how to connect variables in the programming environment to variables in the CSV data file, we found it possible to build as many buyer agents as desired. For those who are interested in more examples and coding strategies using NetLogo, a new book is now available: *Modeling Social Behavior: Mathematical and Agent-Based Models of Social Dynamics and Cultural Evolution* by Paul E. Smaldino (2023). A recent review from the *Journal of Economic Literature* states "This book provides advanced undergraduate or graduate students with a thorough introduction to agent-based models as a tool kit for social studies. To this end, the book relies on a widely adopted software package for agent-based models; NetLogo codes for all the models studied in the book are available and referenced in detail when necessary. This makes it possible for the reader to advance in the study of agent-based models without too much coding skill and experience. While the book reads fundamentally as a textbook, it covers enough material in enough depth to represent an interesting introduction to the literature on social dynamics and cultural evolution, so that it could be profitably read by a social scientist looking for a port of entry into these topics" (Bisin 2024).

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Appendix: NetLogo Code for the Poultry Economy Model

```
extensions [csv]
globals [

  min-price
  population-sellers
  sales-per-tick
  starting-asking-price
  amount-high
  amount-low
  chicks
  fuel-electricity
  feed
  medicine
  transportation
  water
  remaining-costs


  inputdata ;referring to csv files

  ; these variables track data as the model runs
  avg-per-buyer
  avg-per-sellerA
  avg-per-sellerB
  avg-per-sellerC
  total-sales
  remaining-supply
  starting-money-actual
  total-bought

]

breed [ sellersA sellerA ]
breed [ sellersB sellerB ]
breed [ sellersC sellerC ]
breed [ buyers buyer ]
breed [ pops pop ]

turtles-own [
  money       ; keeps track of the amount of money the turtle has
  next-xcor   ; the x-coordinate of the next position
  next-ycor   ; the y-coordinate of the next position
  percent
]
```

```
sellersA-own [
  items-for-saleA ; the quantity that the seller has to sell
  asking-priceA
  asking-price
  starting-supplyA
  behavior-after-sale ; the behavior of seller after a sale
  behavior-no-sale ; the behavior of the seller after a no sale
  sold ; the quantity that the seller has sold

  want-to-buy ; added as a test
  attributes-ownedA
]

sellersB-own [
  items-for-saleB ; the quantity that the seller has to sell
  items-for-saleA
  asking-price
  asking-priceB
  starting-supplyB
  behavior-after-sale ; the behavior of seller after a sale
  behavior-after-saleB
  behavior-no-saleB ; the behavior of the seller after a no sale
  behavior-no-sale
  sold ; the quantity that the seller has sold
  want-to-buy ; added as a test
  attributes-ownedB
]

sellersC-own [
  items-for-saleC ; the quantity that the seller has to sell
  items-for-saleA
  items-for-saleB
  asking-price
  asking-priceB
  asking-priceC
  starting-supplyC
  behavior-after-sale ; the behavior of seller after a sale
  behavior-after-saleC
  behavior-no-saleB ; the behavior of the seller after a no sale
  behavior-no-sale
  sold ; the quantity that the seller has sold
  want-to-buy ; added as a test
  attributes-ownedC
]
```

```
buyers-own [
  want-to-buy ; the quantity the buyer wants to buy
  willing-to-pay
  starting-demand
  behavior-after-purchase
  behavior-no-purchase ; the behavior of the buyer after not buying
  boughtA ; the quantity that the buyer has bought from A
  boughtB ; total bought from seller B
  boughtC
  medicine-costs
  items-for-saleA ;added as test
  items-for-saleB
  items-for-saleC
  starting-priceA
  starting-willing-to-pay

  variable-list var1 var2 var3 ;for get-data command
]

to setup
  clear-all

  directories-and-files

  ; set the global variables
  set min-price 0.01
  ;set population-buyers 3
  set population-sellers 1
  set total-sales 0
  set fuel-electricity 1
  set feed .21
  set water 1
  set medicine .5
  set transportation 1
  set chicks 1.08
  set remaining-costs (6.79 - (chicks + feed))
  set starting-asking-price (chicks + feed + remaining-costs) * 2
  ;set starting-willing-to-pay random 6                    ;starting willing to pay for buyer!
  set amount-high 10
  set amount-low 20
  ;set starting-priceA-global 5
  ;set starting-priceB-global 5
 ; set changing-priceA-global asking-priceA
```

```
 create-ordered-sellersA population-sellers [
  forward 6
  set color blue
  set shape "person"
  setxy -2 2
  set money 0

  set items-for-saleA 1000
  set starting-supplyA items-for-saleA
  set asking-priceA starting-priceA-global
  ;starting asking price for A!!
  set attributes-ownedA attributes-sellerA

  ;set attributes-sellerA "1"
  let mix-behavior ifelse-value seller-behaviorA = "mix of all" [random 3] [-1]
  ifelse seller-behaviorA = "normal" or mix-behavior = 0 [
   set behavior-after-sale [        -> change-priceA 0 ] ;prices changed from 2 and -2 respectively
   set behavior-no-sale    [ hide? -> if (not hide?) [ change-priceA 0] ]
  ] [
   ifelse seller-behaviorA = "desperate" or mix-behavior = 1 [
    set behavior-after-sale [        -> change-priceA 0.7 ]
    set behavior-no-sale    [ hide? -> if (not hide?) [ change-priceA -5.0 ] ]
   ] [
    ; "random" or mix-behavior = 2
    set behavior-after-sale [     -> change-priceA (random 11 - 5)]
    set behavior-no-sale    [     -> change-priceA (random 11 - 5)]
  ] ]
]

 create-ordered-sellersB population-sellers [
  forward 0
  setxy 0 2
  set color green
  set shape "person"
  set money 0

  set items-for-saleA 1000
  set items-for-saleB 1000
  set starting-supplyB items-for-saleB
  set asking-priceB starting-priceB-global
  set attributes-ownedB attributes-sellerB

  let mix-behavior ifelse-value seller-behaviorB = "mix of all" [random 3] [-1]
  ifelse seller-behaviorB = "normal" or mix-behavior = 0 [
   set behavior-after-sale [        -> change-priceB 0 ] ;prices changed from 2 and -2 respectively
   set behavior-no-sale    [ hide? -> if (not hide?) [ change-priceB 0 ] ]
  ] [
   ifelse seller-behaviorB = "desperate" or mix-behavior = 1 [
    set behavior-after-sale [        -> change-priceB 0.7 ]
```

```
    set behavior-no-sale    [ hide? -> if (not hide?) [ change-priceB -5.0 ] ]
   ] [
    ; "random" or mix-behavior = 2
    set behavior-after-sale [     -> change-priceB (random 11 - 5)]
    set behavior-no-sale    [     -> change-priceB (random 11 - 5)]
  ] ]
]

 create-ordered-sellersC population-sellers [
  forward 0
  setxy 2 2
  set color pink
  set shape "person"
  set money 0

  set items-for-saleA 1000
  set items-for-saleB 1000
  set items-for-saleC 1000
  set starting-supplyC items-for-saleC
  set asking-priceC starting-priceC-global
  set attributes-ownedC attributes-sellerC

  let mix-behavior ifelse-value seller-behaviorC = "mix of all" [random 3] [-1]
  ifelse seller-behaviorC = "normal" or mix-behavior = 0 [
   set behavior-after-sale [        -> change-priceC 0 ] ;prices changed from 2 and -2 respectively
   set behavior-no-sale    [ hide? -> if (not hide?) [ change-priceC 0 ] ]
  ] [
   ifelse seller-behaviorC = "desperate" or mix-behavior = 1 [
    set behavior-after-sale [        -> change-priceC 0.7 ]
    set behavior-no-sale    [ hide? -> if (not hide?) [ change-priceC -5.0 ] ]
   ] [
    ; "random" or mix-behavior = 2
    set behavior-after-sale [     -> change-priceC (random 11 - 5)]
    set behavior-no-sale    [     -> change-priceC (random 11 - 5)]
  ] ]
]

 create-ordered-buyers population-buyers [
  forward 10
  facexy 0 0
  set color 58
  ;let new-color [color] of buyer 6 green
  set shape "face happy"
  set items-for-saleA 6;test
  set want-to-buy var2
  set starting-demand want-to-buy
  set money get-starting-value starting-money
  ;set starting-willing-to-pay 5 + random 6
  set starting-willing-to-pay var1
```

```
   set willing-to-pay get-starting-value starting-willing-to-pay * 2

   ask buyers [
    get-data]

   file-close-all

   let mix-behavior ifelse-value buyer-behavior = "mix of all" [random 3] [-1]
   ifelse buyer-behavior = "normal" or mix-behavior = 0 [
    set behavior-after-purchase [-> change-payment 0 ]
    set behavior-no-purchase    [-> change-payment  0]
   ] [
    ifelse buyer-behavior = "desperate" or mix-behavior = 1 [
      set behavior-after-purchase [-> change-payment -1 ]
      set behavior-no-purchase    [-> change-payment  7 ]
    ] [
       ; "random"  or mix-behavior = 2
       set behavior-after-purchase [-> change-payment (random 11 - 5)]
       set behavior-no-purchase    [-> change-payment (random 11 - 5)]
    ]
   ]
  ]

  ; update our tracking variables
  set avg-per-buyer (sum [starting-demand] of buyers) / (count buyers)
  set avg-per-sellerA (sum [starting-supplyA] of sellersA) / (count sellersA)
  set avg-per-sellerB (sum [starting-supplyB] of sellersB) / (count sellersB)
  set avg-per-sellerC (sum [starting-supplyC] of sellersC) / (count sellersC)

  set starting-money-actual sum [money] of buyers

  reset-ticks
end

to-report get-starting-value [ starting-value ]
  report precision (starting-value / 2) 2
end

to go
  if (sum [items-for-saleA] of sellersA = 0 or (0 = count buyers with [money > 0 and want-to-buy > 0])) [
stop ]
  if (sum [items-for-saleB] of sellersB = 0 or (0 = count buyers with [money > 0 and want-to-buy > 0])) [
stop ]
  if (sum [items-for-saleC] of sellersC = 0 or (0 = count buyers with [money > 0 and want-to-buy > 0])) [
stop ]

  clear-drawing
  set sales-per-tick 0
```

```
  set remaining-supply (sum [items-for-saleA] of sellersA + sum [items-for-saleB] of sellersB + sum
[items-for-saleC] of sellersC)
  set total-bought (sum [boughtA] of buyers + sum [boughtB] of buyers + sum [boughtC] of buyers)

let sellersA-commerce sellersA
  ask buyers [ do-commerce-withA sellersA-commerce ]
  ask buyers [update-buyer-display]
  ask sellersA [update-seller-displayA]
  set total-sales (total-sales + sales-per-tick)

 let sellersB-commerce sellersB
  ask buyers [ do-commerce-withB sellersB-commerce ]
  ask buyers [update-buyer-display]
  ask sellersB [update-seller-displayB]
  set total-sales (total-sales + sales-per-tick)

 let sellersC-commerce sellersC
  ask buyers [ do-commerce-withC sellersC-commerce ]
  ask buyers [update-buyer-display]
  ask sellersC [update-seller-displayC]
  set total-sales (total-sales + sales-per-tick)


  ; sanity check
  if (any? buyers with [want-to-buy > 0 and willing-to-pay > money]) [ error "Cannot have buyers that
want to pay more than they have cash available!" ]

  tick
end

to update-buyer-display
  if want-to-buy = 0 [
    set color 2
  ]
  set size 1 + (boughtA + boughtB + boughtC / avg-per-buyer) * .01
end

to update-seller-displayA
  if items-for-saleA = 0 [ set color 2 ]
end

to update-seller-displayB
  if items-for-saleB = 0 [ set color 2 ]
end

to update-seller-displayC
  if items-for-saleB = 0 [ set color 2 ]
end
```

```
to do-commerce-withA [sellersA-commerce]
  let asking [asking-priceA] of sellerA 0
  let attributes-desiredA [attributes-ownedA] of sellerA 0
  let attributes-desiredB [attributes-ownedB] of sellerB 1
  let attributes-desiredC [attributes-ownedC] of sellerC 2


  (ifelse
    ;attributes-desiredA = "1" [                ;changed "1" to var3
    attributes-sellerA = var3 [
    create-link sellersA self pink

    set sales-per-tick (sales-per-tick + 1)
    set want-to-buy (want-to-buy - 1)
    let price asking
    set money precision (money - price) 2
    set money ifelse-value money < min-price [0] [money]
    set boughtA (boughtA + 1)
    ask sellersA [
      set items-for-saleA (items-for-saleA - 1)
      set money precision (money + price) 2
      set sold (sold + 1)
      run behavior-after-sale
      ]
    run behavior-after-purchase
      ]


    attributes-sellerB = var3 or attributes-sellerC = var3 [                    ;changed "1" to var3
    create-link sellersA self blue
    let hide? (sellers-ignore-full-buyers? and (want-to-buy = 0))
    ask sellersA [ (run behavior-no-sale hide?) ]
    run behavior-no-purchase
  ]
    items-for-saleA > 0 and want-to-buy > 0 and asking <= money and asking <= willing-to-pay and
attributes-sellerA != var3 and asking < [asking-priceB] of sellerB 1 and asking < [asking-priceC] of
sellerC 2[          ;changed "1" to var3
  create-link sellersA self yellow                    ;if causing issues, remove the "and asking <
[asking-priceB] of sellerB 1 and asking < [asking-priceC] of sellerC 2

      set sales-per-tick (sales-per-tick + 1)
    set want-to-buy (want-to-buy - 1)
    let price asking
    set money precision (money - price) 2
    set money ifelse-value money < min-price [0] [money]
    set boughtA (boughtA + 1)
    ask sellersA [
      set items-for-saleA (items-for-saleA - 1)
      set money precision (money + price) 2
```

```
    set sold (sold + 1)
    run behavior-after-sale
   ]
  run behavior-after-purchase
   ]
      [
   ; else no purchase was made
   create-link sellersA self blue
   let hide? (sellers-ignore-full-buyers? and (want-to-buy = 0))
   ask sellersA [ (run behavior-no-sale hide?) ]
   run behavior-no-purchase
 ])
end

to do-commerce-withB [sellersB-commerce]
  let asking [asking-priceB] of sellerB 1
 let attributes-desiredB [attributes-ownedB] of sellerB 1
  let attributes-desiredA [attributes-ownedA] of sellerA 0
  let attributes-desiredC [attributes-ownedC] of sellerC 2


(ifelse
   ;attributes-desiredB = "1" [
    attributes-sellerB = var3 [
   create-link sellersB self pink

   set sales-per-tick (sales-per-tick + 1)
   set want-to-buy (want-to-buy - 1)
   let price asking
   set money precision (money - price) 2
   set money ifelse-value money < min-price [0] [money]
   set boughtB (boughtB + 1)
   ask sellersB [
    set items-for-saleB (items-for-saleB - 1)
    set money precision (money + price) 2
    set sold (sold + 1)
    run behavior-after-sale
    ]
   run behavior-after-purchase
  ]
   attributes-sellerA = var3 or attributes-sellerC = var3 [
   create-link sellersB self blue
   let hide? (sellers-ignore-full-buyers? and (want-to-buy = 0))
   ask sellersB [ (run behavior-no-sale hide?) ]
   run behavior-no-purchase
  ]
```

```
 items-for-saleB > -1 and want-to-buy > 0 and asking <= money and asking <= willing-to-pay and
attributes-sellerB != var3 and asking < [asking-priceA] of sellerA 0 and asking < [asking-priceC] of
sellerC 2[
  create-link sellersB self yellow

     set sales-per-tick (sales-per-tick + 1)
    set want-to-buy (want-to-buy - 1)
    let price asking
    set money precision (money - price) 2
    set money ifelse-value money < min-price [0] [money]
    set boughtB (boughtB + 1)
    ask sellersB [
     set items-for-saleB (items-for-saleB - 1)
     set money precision (money + price) 2
     set sold (sold + 1)
     run behavior-after-sale
    ]
   run behavior-after-purchase
    ]
        [
    ; else no purchase was made
    create-link sellersB self blue
    let hide? (sellers-ignore-full-buyers? and (want-to-buy = 0))
    ask sellersB [ (run behavior-no-sale hide?) ]
    run behavior-no-purchase
  ])
end

to do-commerce-withC [sellersC-commerce]
  let asking [asking-priceC] of sellerC 2
  let attributes-desiredA [attributes-ownedA] of sellerA 0
  let attributes-desiredB [attributes-ownedB] of sellerB 1
  let attributes-desiredC [attributes-ownedC] of sellerC 2


  (ifelse
    ;attributes-desiredC = "1" [
     attributes-sellerC = var3 [
    create-link sellersC self pink

    set sales-per-tick (sales-per-tick + 1)
    set want-to-buy (want-to-buy - 1)
    let price asking
    set money precision (money - price) 2
    set money ifelse-value money < min-price [0] [money]
    set boughtC (boughtC + 1)
    ask sellersC [
     set items-for-saleC (items-for-saleC - 1)
     set money precision (money + price) 2
```

```
    set sold (sold + 1)
    run behavior-after-sale
    ]
   run behavior-after-purchase
  ]
   attributes-sellerA = "1" or attributes-sellerB = var3 [
   create-link sellersC self blue
   let hide? (sellers-ignore-full-buyers? and (want-to-buy = 0))
   ask sellersC [ (run behavior-no-sale hide?) ]
   run behavior-no-purchase
  ]

 items-for-saleC > -1 and want-to-buy > 0 and asking <= money and asking <= willing-to-pay and
attributes-sellerC != var3 and asking < [asking-priceB] of sellerB 1 and asking < [asking-priceA] of
sellerA 0 [
  create-link sellersC self yellow

    set sales-per-tick (sales-per-tick + 1)
   set want-to-buy (want-to-buy - 1)
   let price asking
   set money precision (money - price) 2
   set money ifelse-value money < min-price [0] [money]
   set boughtC (boughtC + 1)
   ask sellersC [
    set items-for-saleC (items-for-saleC - 1)
    set money precision (money + price) 2
    set sold (sold + 1)
    run behavior-after-sale
   ]
   run behavior-after-purchase
   ]
      [
   ; else no purchase was made
   create-link sellersC self blue
   let hide? (sellers-ignore-full-buyers? and (want-to-buy = 0))
   ask sellersC [ (run behavior-no-sale hide?) ]
   run behavior-no-purchase
  ])
end

to create-link [ some-seller some-buyer some-color ]
  ask some-seller [
   let oc color
   let x xcor
   let y ycor
   set color some-color
   set pen-size 3
   pen-down
   move-to some-buyer
```

```
    pen-up
    setxy x y
    set color oc
  ]
end

to change-priceA [ change ]
  let before asking-priceA
  set percent 1 + (change / 100)
  set asking-priceA check-for-min-price (precision (percent * asking-priceA) 2)
  if before = asking-priceA [
    if change < 0 and before != min-price [
      set asking-price precision (asking-price - min-price) 2
    ]
    if change > 0 [
      set asking-price precision (asking-price + min-price) 2
    ]
  ]
end

to change-priceB [ change ]
  let before asking-priceB
  set percent 1 + (change / 100)
  set asking-priceB check-for-min-price (precision (percent * asking-priceB) 2)
  if before = asking-priceB [
    if change < 0 and before != min-price [
      set asking-price precision (asking-price - min-price) 2
    ]
    if change > 0 [
      set asking-price precision (asking-price + min-price) 2
    ]
  ]
end

to change-priceC [ change ]
  let before asking-priceC
  set percent 1 + (change / 100)
  set asking-priceC check-for-min-price (precision (percent * asking-priceC) 2)
  if before = asking-priceC [
    if change < 0 and before != min-price [
      set asking-price precision (asking-price - min-price) 2
    ]
    if change > 0 [
      set asking-price precision (asking-price + min-price) 2
    ]
  ]
end

to change-payment [ change ]
```

```
  let before willing-to-pay
  set percent 1 + (change / 100)
  set willing-to-pay check-for-min-price (precision (percent * willing-to-pay) 2)
  if before = willing-to-pay [
    if change < 0 and before != min-price [
      set willing-to-pay precision (willing-to-pay - min-price) 2
    ]
    if change > 0 [
      set willing-to-pay precision (willing-to-pay + min-price) 2
    ]
  ]
  if willing-to-pay > money [ set willing-to-pay money ]
end

to-report seller-cash
  report sum [money] of sellersA + sum [money] of sellersB + sum [money] of sellersC
end

to-report total-bought-per-buyer
  report total-bought
end

to-report average-price
  report (ifelse-value total-sales = 0 [ 0.00 ] [ precision (seller-cash / total-sales) 2 * 3])
end

to-report percent-money-taken
  report 100 * sum [money] of sellersA / starting-money-actual + 100 * sum [money] of sellersB /
starting-money-actual + 100 * sum [money] of sellersC / starting-money-actual
end

to-report remaining-products-to-be-sold
  report remaining-supply
end

to-report remaining-starting-money
  report starting-money - sum [money] of sellersA - sum [money] of sellersB
end

to-report percent-items-sold
  report 100 * sum [sold] of sellersA / sum [items-for-saleA + sold] of sellersA
end

to-report percent-demand-satisfied
  report 100 * sum [boughtA] of buyers / sum [want-to-buy + boughtA] of buyers
end

to-report check-for-min-price [ value ]
  report precision ifelse-value value < min-price [min-price] [value] 2
```

```
end

to directories-and-files
  set inputdata csv:from-file "C:/ABM Work/test.csv"
end

to get-data
  set variable-list []

  set variable-list item (who + 1) inputdata

  set var1 item 0 variable-list
  set var2 item 1 variable-list
  set var3 item 2 variable-list

end

;Copyright Bryan Collins 2023
;Coding ideas pulled from NetLogo Bidding Market Model
;Baker, J. and Wilensky, U. (2017). NetLogo Bidding Market model.
http://ccl.northwestern.edu/netlogo/models/BiddingMarket. Center for Connected Learning and
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Extension Education

Farmland Price-Rent Surveys: Opportunities for Outreach and Teaching

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Abstract
Across North America, applied economists conduct annual surveys to assess local farmland prices and farmland rental rates. In this paper, we discuss the "Ontario Farmland Value and Rental Value Survey" and explain how the survey results support university outreach and teaching efforts. Similar to other surveys, the Ontario survey provides benchmark rental rates and farmland values at the county level that are beneficial for outreach purposes. In addition, the survey illuminates key economic relationships, such as the relationship between farmland values and urban development pressure. In teaching settings, the survey results allow students to assess and debate the merits of the classic capitalization formula using information regarding familiar regions.

1 Introduction

The relationship between rental rates and interest rates is a fundamental consideration in understanding the evolution of farmland prices. While interest rates and farmland values are well known and often well-reported, access to rental rate information is more limited. Consequently, universities throughout North America conduct annual surveys that monitor farmland values and rental rates (see Table 1 for examples of these surveys). In the United States, examples of these surveys include the "Purdue Farmland Values and Cash Rents Survey," conducted in Indiana (Center for Commercial Agriculture, Purdue University 2024), or the survey conducted by the Illinois Society of Professional Farm Managers and Rural Appraisers (ISPFMRA; 2023). In Ontario, the "Ontario Farmland Value and Rental Value Survey" (OFVRVS), the focus of this paper, is the only source of farmland rental rates made available on an annual basis. The OFVRVS surveys Ontario farmers and farmland owners on farmland prices and rental rates for farmland in their region (Deaton 2021). In this paper, we discuss how the OFVRVS is used to support outreach and enhance teaching outcomes.

One critical aspect of the OFVRVS is that it provides farmers and farmland owners with a benchmark for rental rates in their area. This allows survey users to understand the significant variation in farmland markets across regions. Beyond providing a benchmark rental rate for farmers and farmland owners, the survey allows for outreach regarding key economic phenomena. One example includes the well-established capitalization model, which emphasizes the economic relationship between rental rates, interest rates, and the price of farmland. Developing an understanding of this relationship is important for both outreach purposes and teaching.

Section 2 of this paper provides background on the OFVRVS. We address the following questions: When and why did the survey emerge? What methods are used to collect the information? Who presently uses the survey? The following section, Section 3, explains ways the survey is used in outreach settings to benchmark key information relevant to producers, landlords, and policy makers. Section 3 also illustrates the capacity of the survey to appreciate and assess economic fundamentals using the classic capitalization formula. Section 4 conceptualizes farmland as a dividend-bearing asset and compares its returns to other dividend-bearing stocks. This conceptualization is also useful for helping

Table 1. Examples of Farmland Value and Rent Surveys in North America.

Survey	University/ Organization	Location	Link
Ontario Farmland Value and Rental Value Survey	University of Guelph	Ontario, Canada	https://www.onfarmlandsurvey.com/
Purdue Farmland Values and Cash Rents Survey	Purdue University	Indiana, USA	https://ag.purdue.edu/department/agecon/extension/farmland-values.html
Illinois Farmland Values and Lease Trends	Illinois Society of Professional Farm Managers and Rural Appraisers	Illinois, USA	https://ispfmra.org/land-values-archive/
Nebraska Farm Real Estate Market Survey	University of Nebraska	Nebraska, USA	https://extension.unl.edu/statewide/cedar/connect-us/agricultural-farm-ranch-resources/
FINBIN – Farm Financial Database	University of Minnesota	Minnesota, USA	https://extension.umn.edu/farmland-rent-and-economics/cropland-rental-rates
Cash Rental Rates for Iowa	Iowa State University	Iowa, USA	https://www.extension.iastate.edu/agdm/wholefarm/html/c2-10.html
Western Ohio Cropland Values and Cash Rents	Ohio State University	Ohio, USA	https://farmoffice.osu.edu/farm-management-tools/farm-management-publications/cash-rents

Notes: Surveys provided in the above table are meant to provide an example of some of the farmland value and rent surveys conducted across North America. The list does not include all surveys.

survey users appreciate the relationship between farmland values and rental rates and other common forms of investment. In Section 5, we describe an in-class exercise that can be used to deepen students' appreciation of farmland rental information and key economic relationships. Finally, in Section 6, we describe some best practices for managing an extension product based on our learned experiences.

2 Background

Across Canada, 38 percent of farmland is in the rental market (Statistics Canada 2022).[1] While there are regional differences in the composition of rental markets across Canada, a similar percentage (29 percent) of farmland is rented out in Canada's most populous province of Ontario, where 40 percent of Canadians live (the majority of which live in non-rural population centers).[2] The large share of farmland in Ontario's rental market makes it even more surprising that prior to the beginning of the OFVRVS in 2016, there was no public provision of farmland rental rates at the county level in Ontario. Unlike in the United States, where the 2008 Farm Bill mandated that the National Agricultural Statistics Service (NASS) provide average annual rental rates for every U.S. County with more than 20,000 acres of cropland, Statistics Canada does not provide information to the public about Canadian farmland rental rates (U.S. Department of Agriculture 2024). The lack of publicly available data was a major reason why the University of Guelph, with financial support from the Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA), initiated the OFVRVS in 2016.[3]

From the onset of the proposed survey, a farmland study group comprising academics, government representatives, farmer organization representatives, realtors, and the Municipal Property

[1] Calculated by dividing the total land rented from both government and others by the total farmland area reported in the 2021 Census of Agriculture.

[2] This was Statistics Canada's (2023) count as of January 2023; 13.8 percent of Ontario's population resides in population centers that are considered rural (Statista Research Department 2024). There are provincial differences in the composition of the rental market in Canada, including differences in the percentage of farmland leased out by the government.

[3] Brady Deaton was the P.I. on the Grant. Steve Duff, Chief Economist of OMAFRA, played a significant role in supporting the project in a manner that would ensure ongoing surveys on an annual basis. It should be noted that the initial design of the survey was informed by earlier rental survey studies in Ontario (Bryan, Deaton, and Weersink 2015; Deaton, Lawley, and Nadella 2018).

Assessment Corporation (MPAC),[4] was assembled to help design the survey. This additional consideration of the survey design has implications for outreach, as members of this initial study group provide ongoing oversight of the survey via an annual meeting. Moreover, this group is critical for supporting responses to the survey and assisting with outreach regarding the survey results.

One major way the farmland study group contributes to the survey is by helping to establish a sample of respondents. For the 2016–2021 surveys, the survey was sent to only members of the Ontario Farmers Association (OFA). Starting with the 2022 survey round, the survey's respondent pool was expanded beyond OFA members to include members of two additional farmer-led organizations in Ontario: the National Farmers Union (NFU) and the Christian Farmers Federation of Ontario (CFFO). [8] All farm businesses in Ontario reporting at least $7,000 in gross farm revenue must register their farm business to one of the three accredited farm organizations: OFA, NFU, or CFFO. By including members of these three farm groups in the survey sample, the survey sample pool includes nearly all farm businesses in the province.

Beginning in January of each year, an initial email is sent to the respondent pool with a link to the online survey. The survey asks respondents questions about the previous year's rental rate and farmland values. Following the initial email, two additional reminder emails are sent over the span of two weeks. While the response rate varies each year, the 2023 survey recorded 1,116 respondents, implying a response rate of approximately 4 percent. The results of the survey are posted online at www.onfarmlandsurvey.com.

The OFVRVS provides valuable information beyond farmland rental rates and farmland prices. For instance, the survey also gathers information about the characteristics of each respondent, their relationship to the agricultural sector (farmland owner, active farmer, landlord, tenant, etc.) and farmland use information. Details about farmland use include the ratio of acres rented to owned, the number of landlords, and whether landlords require stipulations. A recent addition of the survey includes asking respondents about their perceptions with respect to current and future farmland prices. This subset of questions was included to gauge overall market sentiment and explore whether respondent perceptions accurately describe trends in Ontario farmland markets.

3 Outreach: Benchmarking Farmland Rental Rates

For the purposes of this paper, Extension efforts achieve an Extension product when the information provided influences the intended user's decision to act (or forbearance).[5] When, for example, new policies, or market shocks occur, farmers often rely on Extension economists to concisely communicate the implications for them and their operation (Martinez et al. 2022). In this regard, Extension programs play a crucial role in informing the decision-making process of farmers, and thriving Extension programs act as a "bridge" between universities and the agricultural community (Marshall et al. 2022).

The lack of rental information makes it difficult for Ontario farmers and farmland owners to *benchmark* their experiences, assess their situation, and alter decisions if needed. Moreover, because many farmers and landlords have investment opportunities that span across jurisdictions, the lack of information diminishes their potential to assess differences across regions. Consequently, one primary Extension product of the OFVRVS is to enhance the capacity of individuals to benchmark their personal observations of rents and land values with the survey results. Unsurprisingly, the survey results that appear to generate the highest user interest describe farmland rental rates and farmland values by region. The regions correspond with Statistics Canada's Census Division (hereafter referred to as

[4] MPAC is responsible for assessing the property values for all of Ontario. Municipalities use these assessments for property tax purposes.

[8] The OFA email list has 25,017 emails as of 2023. The CFFO has 2,976, and the NFU has 2,200.

[5] We credit the late Dr. Paxton Marshall (former extension Professor at Virginia Tech) for heavily influencing this working definition of the Extension product.

counties) boundaries. While some of the counties are technically regional municipalities, they often retain their historical description as "counties."

With respect to the OFVRVS and the importance of benchmarking, the survey results provide users with three valuable pieces of information about farmland markets in their county: median rental rate for average quality farmland, median price for average quality farmland, and the rent-to-price ratio (calculated as median rent divided by median farmland value). In outreach presentations and seminars, we explain these three metrics and allow for a discussion about them with the audience. For example, the 2023 survey published a median rental rate of $350 per acre and a median farmland value of $26,400 per acre in Huron County, resulting in a rent-to-price ratio of 1.3 percent.

By providing farmers and farmland owners with this information online and in outreach settings, users are then able to benchmark the published values against what they purchase and rent farmland for. While the published values are not designed to be used to set precise rental rates or farmland prices, they give users a gauge of where the prices they pay to rent and buy their farmland sit relative to average quality land in their county. Farmers, tenants, and landlords alike can assess their existing rental relationships according to this information and consider a host of additional issues including the quality of the farmland relative to average quality cropland.

In addition to providing rental rates and farmland values, the rent-to-price ratio is a particularly useful benchmark because it identifies a capitalization rate or "cap rate," which is used to evaluate and compare investments. The 2023 survey published cap rates ranging from 2 percent in Stormont, Dundas, and Glengarry to 0.5 percent in Northumberland. A high cap rate relative to other investments suggests the investment is viable compared to alternatives. Consequently, users can obtain this information and benchmark it against specific alternatives and prevailing interest rates. In addition, variation in cap rates illuminates important geographic differences between agricultural counties. In some cases, low cap rates are associated with urbanizing areas (e.g., Niagara) where future non-agricultural uses of farmland place upward pressure on farmland values and rental rates are relatively low. In these areas, the very low cap rates suggest that farmland rental rates alone do not accurately explain the future annual net-returns that may be associated with non-agricultural uses. In outreach settings, providing users with an explanation of the "cap rate" is useful for exploring the heterogeneity of farmland rental markets across Ontario.

The value of providing rental rate and farmland price information at the county level is apparent when comparing the reported farmland values and rental rates for a single county to other Ontario counties. To illustrate the heterogeneity in farmland markets across Ontario counties, Figure 1 provides box-whisker plots for Ontario farmland values and rental rates in 2023. Per-acre, county median rental rates (for average quality farmland) vary from $50 to $350, with the median being close to $250.[6] County farmland values at the median also vary considerably: between $8,000 and $36,000 per acre. Hence, an important takeaway is that there is tremendous variation in farmland values and rental rates across Ontario. Although the survey is not instructive on rental rates for a specific parcel, it provides respondents (members of the three accredited farm organizations) and other users with rental information about farmland in their county. In this regard, the survey is particularly beneficial for benchmarking one's individual experience of rental rates and farmland values with the county they live in.

Additionally, as discussed earlier with respect to cap rates, the survey recognizes geographic

[6] All Canadian monetary figures are in Canadian Dollars.

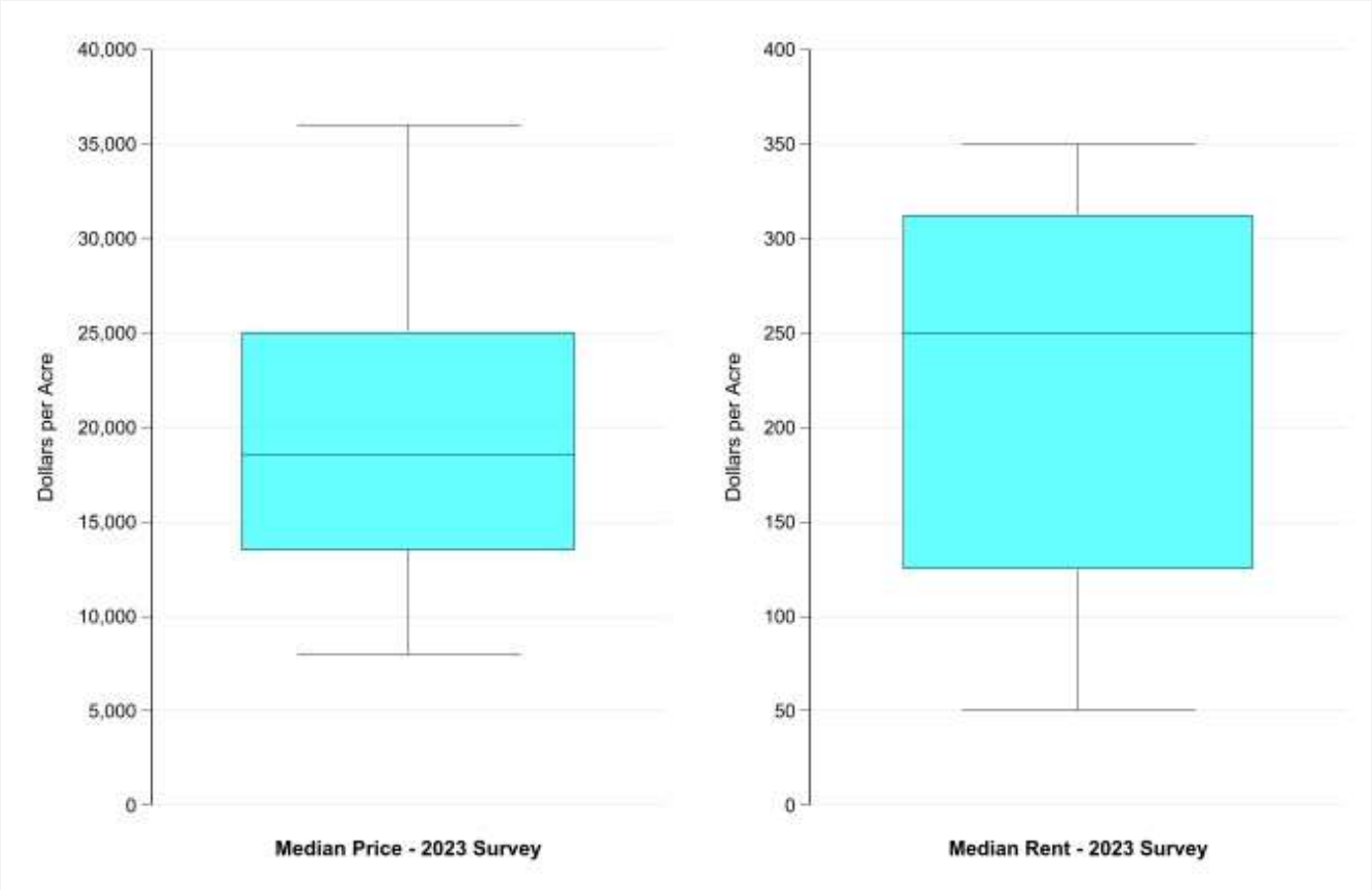

Figure 1. Median Price and Cash Rent Reported in 2023 OFVRVS.

variation in respondents' perceptions of farmland purchases. In general, in many near-urban counties, respondents view most farmland buyers as "non-farmers." For instance, Table 2 shows that respondents consider only 35 percent of farmland purchasers to be "farmers" in Niagara. Farmland parcels in Niagara are close to urban centers and have unique climate characteristics that allow for speciality fruits and vegetables to grow. This observation contrasts to Perth County, where respondents consider 100 percent of purchasers to be "farmers." Farmland in Perth County is also more likely to be used for a traditional corn-soy rotation and is more removed from urban development pressure than farmland in a county such as Niagara.

Both of the above examples allow users of the survey to benchmark their own understanding of farmland market outcomes in their region against the survey results. Importantly, the survey provides respondents with information that is not generally available. Providing this information to stakeholders is a focus of outreach efforts related to the survey. Given the significant heterogeneity in farmland market outcomes in Ontario, the OFVRVS allows survey users to annually assess their own experiences against the survey results and consider the extent to which the information warrants changed decisions.

A second Extension product relates to using information from the OFVRVS to better *appreciate and assess fundamental economic relationships* (e.g., the relationship between farmland values, rental rates, and interest rates). This is an important aspect of the OFVRVS because it allows for outreach and ongoing discussion about economic fundamentals.

For instance, in the 2023 survey, median rental rates are highest in Chatham-Kent, Huron,

Table 2. Perceptions of Farmland Purchases Made by Farmers – 2023 Survey.

Region	Perceived Percentage of Farmland Purchases Made by Farmers [*median reported*]
Algoma (District)	90% (n = 5)
Brant (Census Division)	65% (n = 6)
Bruce (County)	90% (n = 27)
Chatham-Kent (Census Division)	75% (n = 18)
Durham (Regional Municipality)	40% (n = 6)
Elgin (County)	90% (n = 21)
Essex (County)	50% (n = 12)
Grey (County)	80% (n = 11)
Haldimand (County)	73% (n = 8)
Huron (County)	88% (n = 38)
Kawartha Lakes (Census Division)	70% (n = 5)
Lambton (County)	85% (n = 26)
Lanark (County)	25% (n = 5)
Leeds and Grenville (United Counties)	70% (n = 5)
Middlesex (County)	68% (n = 30)
Niagara (Regional Municipality)	35% (n = 14)
Norfolk (County)	63% (n = 12)
Northumberland (County)	55% (n = 7)
Ottawa (Census Division)	70% (n = 13)
Oxford (County)	85% (n = 19)
Peel (Regional Municipality)[1]	8% (n = 8)
Perth (County)	100% (n = 30)
Peterborough (County)	25% (n = 11)
Prince Edward (Census Division)[2]	25% (n = 5)
Renfrew (County)	93% (n = 20)
Simcoe (County)	53% (n = 16)
Stormont, Dundas and Glengarry (United Counties)	70% (n = 17)
Wellington (County)	50% (n = 18)

[1]The mean percentage in Peel is significantly higher than the median, at approximately 17 percent.
[2]The mean percentage in Prince Edward is significantly higher than the median, at approximately 40 percent.

Middlesex, Oxford, and Perth Counties, at $350 per acre. The following equation presents a simple capitalization model where present land values are reflective of the discounted stream of future rents:

$$Present\ Land\ Value = \frac{Rental\ Rate}{Interest\ Rate} \quad (1)$$

In this simple capitalization model, if interest rates are held constant, it follows that counties with high rental rates also have relatively high land values. Consistent with expectations from the simple capitalization model, Chatham-Kent, Huron, Middlesex, Oxford, and Perth all have some of the highest reported median per-acre land values and rental rates of counties included in the survey. In this sense, the survey is useful in outreach and classroom settings because individuals are provided with empirical data to support theoretical models.

In many outreach settings, the simple capitalization model (Equation 1) can be used to explore key economic relationships. The many assumptions associated with this model—for example, the appropriate interest rate and the stability of expectations regarding rental rates and the amount of farmland remaining in farming—become important nuances to be developed. As outreach discussions become more nuanced, a more complete capitalization model can be developed and in-depth discussion about the critiques of this model can be supported by discussions drawn from the literature (see Deaton and Lawley 2022). The expanded capitalization model extends the simple capitalization (Equation 1) into two distinct pieces: the discounted returns from agricultural production and the discounted returns from future conversion of farmland to non-farm uses. This expanded capitalization model is particularly relevant in the context of Southern Ontario, where urban pressure has placed upward pressure on land values due to the potential net-returns that can be generated from developing farmland for non-agricultural uses.[7]

For example, in the 2023 survey, the county of Durham has a median reported rent of $150 per acre and median farmland values of $16,500 per acre. Assuming an interest rate of 5 percent and a rental rate of $150 per acre, Equation 1 would predict farmland values of only $3,000 per acre. This prediction leaves a large share of the reported farmland values in Durham County unexplained. Expanding the capitalization model to include returns from the future development of farmland suggests that the unexplained portion of farmland values in Durham is a function of the expected returns from alternative future uses. Given Durham's proximity to the Greater Toronto area, it is reasonable to expect that farmland valuations in Durham are influenced by their potential conversion to non-agricultural uses. Exploring the capitalization model and the relationship between farmland values and non-agricultural influences, is extremely powerful as a teaching or presentation tool. While students and producer groups may not fully appreciate the nuances of the capitalization model, they can use the survey results and relate their understanding of farmland markets in their own and nearby counties to better understand it and its implications.

A second way that the survey results can illustrate how non-agricultural influences impact farmland valuations is through an analysis of how proximity to urban areas impact farmland values. In the 2023 survey, respondents are asked to describe the amount of time it takes (without traffic) to Toronto's major airport (Pearson).[8] We plot the relationship between farmland prices and the distance to

[7] A full capitalization model, as introduced by Brueckner (1990), is provided below. See Deaton and Lawley (2022) for an in-depth discussion.

$$V_a(t) = \int_0^{t*} r_a(t)e^{-it}dt \ + \ \int_{t*}^{\infty} r_u(t)e^{-it}dt \ - \ Ce^{-it}$$

Where farmland values, V_a, at time t, are a function of both the discounted stream of net returns from agricultural production, r_a, and the returns from an alternative use, r_u. In this model, farmland is assumed to remain in production until time t^*, at which time it is converted to an alternative use (e.g., urban development, residential). The model also considers the cost of converting the farmland parcel to an alternative use, C. i, represents the interest rate.

[8] Pearson Airport was selected as a landmark in Toronto that respondents would be familiar with.

Pearson Airport in Figure 2.[9] Consistent with expectations, the figure shows a clear negative relationship between farmland values and the distance to Pearson Airport (i.e., farmland values decrease as the distance to Pearson increases). Figure 2 provides a very simple, yet powerful illustration of how farmland values are influenced by urban centers that is useful in both teaching and outreach settings. Once again, this result also helps to underscore the significant spatial heterogeneity in Ontario farmland markets, a consistent theme in the survey results and an important point to emphasize during outreach presentations.

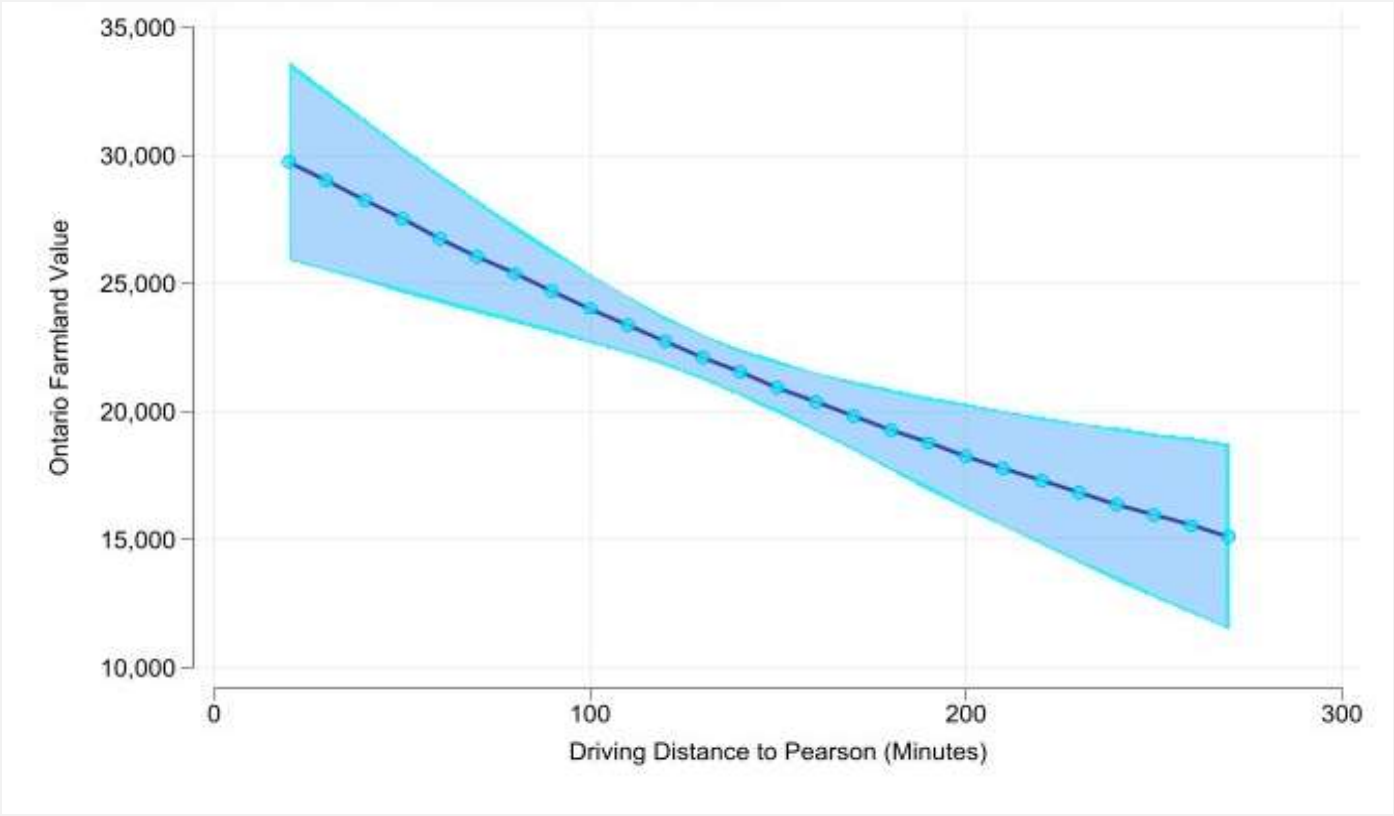

Figure 2. Farmland Value and Driving Distance to Pearson – 2023 Survey.

Anecdotally, in the section of the survey where respondents are asked to write in any comments they have about the survey, respondents often ask why a question about the distance of their farm to Pearson is included. Hence, the value of developing varying measures of urban proximity through the survey may not be self-evident. Considering this, providing outreach groups with Figure 2, which illustrates the relationship between farmland prices and proximity to Pearson Airport (one measure of urban proximity), aids understanding of urban pressure on farmland prices by anchoring farmland prices near a familiar urban point and noting how farmland prices decline as farms become increasingly remote.

4 Outreach: Conceptualizing Farmland Appreciation and Rent

Another way to help survey users grasp economic aspects of farmland prices and rental rates is to conceptualize the return to farmland as comprising an annual dividend payment (i.e., an annual rental payment) and appreciation. In this way, farmland can be conceptualized as a stock with dividend

[9] Specifically, Figure 2 plots marginal effects obtained from a regression model controlling for farmland quality, distance to large cities, and fixed effects for each county.

payments (Painter 2009). Analyzing the survey in this manner allows for an exploration of the results beyond singular per-acre values and rental rates. This also helps enhance the value of the Extension product in teaching and outreach settings.

To begin to conceptualize farmland as a dividend paying stock, we break down the return on investment into two constituent parts for each county: lease income yield and annual appreciation. We measure lease income yield as the ratio of the rental rate less property tax to the price of farmland.[10] Annualized appreciation over the seven-year period from 2016 to 2023 is calculated in the following equation:

$$\left(\frac{Price_{2023}}{Price_{2016}}\right)^{\frac{1}{7}} - 1 \qquad (2)$$

We then plot the relationship between lease-income yield and annual appreciation by county in Figure 3 and compare it to the 30-year average dividend return for the S&P 500 stock index.[11]

Figure 3 highlights a couple of important points. First, and underscoring the earlier point, returns to farmland vary considerably across the province. Lease-income yields range from less than 0.5 percent in Niagara to 1.7 percent in Norfolk. Second, while the dividend returns for the S&P 500 index were not adjusted for taxes, lease-income yields are relatively low compared with dividend returns from the S&P 500 index.

In this scenario, the S&P 500 index represents an alternative investment to investing capital in farmland. For an investor primarily interested in dividend yield, or lease-income yield, the survey results illustrate that, on average, the S&P 500 yields higher dividend returns. However, there are certain counties (e.g., Bruce, Essex, and Norfolk) where the lease-income yield is close to the 30-year average S&P 500 dividend return. This point helps to re-emphasize a recurring theme of the survey, that returns to farming vary substantially across Ontario. Interestingly, and related to an earlier point, respondents from Essex County indicated that a high share (50 percent) of farmland is being bought by "non-farmers."

Aside from the few cases discussed above, lease-income yields are low in most Ontario counties. This observation is consistent with the long-standing concern that farmland does not cash-flow well. However, compared to the S&P 500, the annual appreciation appears to be slightly higher than that of the index. The average annualization appreciation of median farmland values in the survey is 9.5 percent, compared to a 8.3 percent annualized appreciation rate of the S&P 500 over a 30-year period. In this regard, information from the OFVRVS corresponds reasonably well to the performance of other comparable financial instruments. And our experience is that this comparison is interesting in outreach and educational settings, particularly when illustrating how the returns to farmland vary geographically and compared to alternative investments.

5 Classroom Ideas

In this section, we explain how the OFVRVS is used in an undergraduate class. While we focus specifically on the applications of the survey in a fourth-year undergraduate land economics course, the underlying concepts are applicable to a variety of economic courses from the first-year level all the way to graduate classes.[12]

[10] Property tax is calculated using the average farm tax rate for certain municipalities in each county. Since the exact location of a respondent is not known, the tax rate is an approximation.

[11] The S&P 500 is an index, tracking the performance of the 500 largest companies listed on U.S. stock exchanges. It serves as a benchmark of investment performance.

[12] The land economics course referenced in this section is FARE*4290, Land Economics taught by B. James Deaton at the University of Guelph.

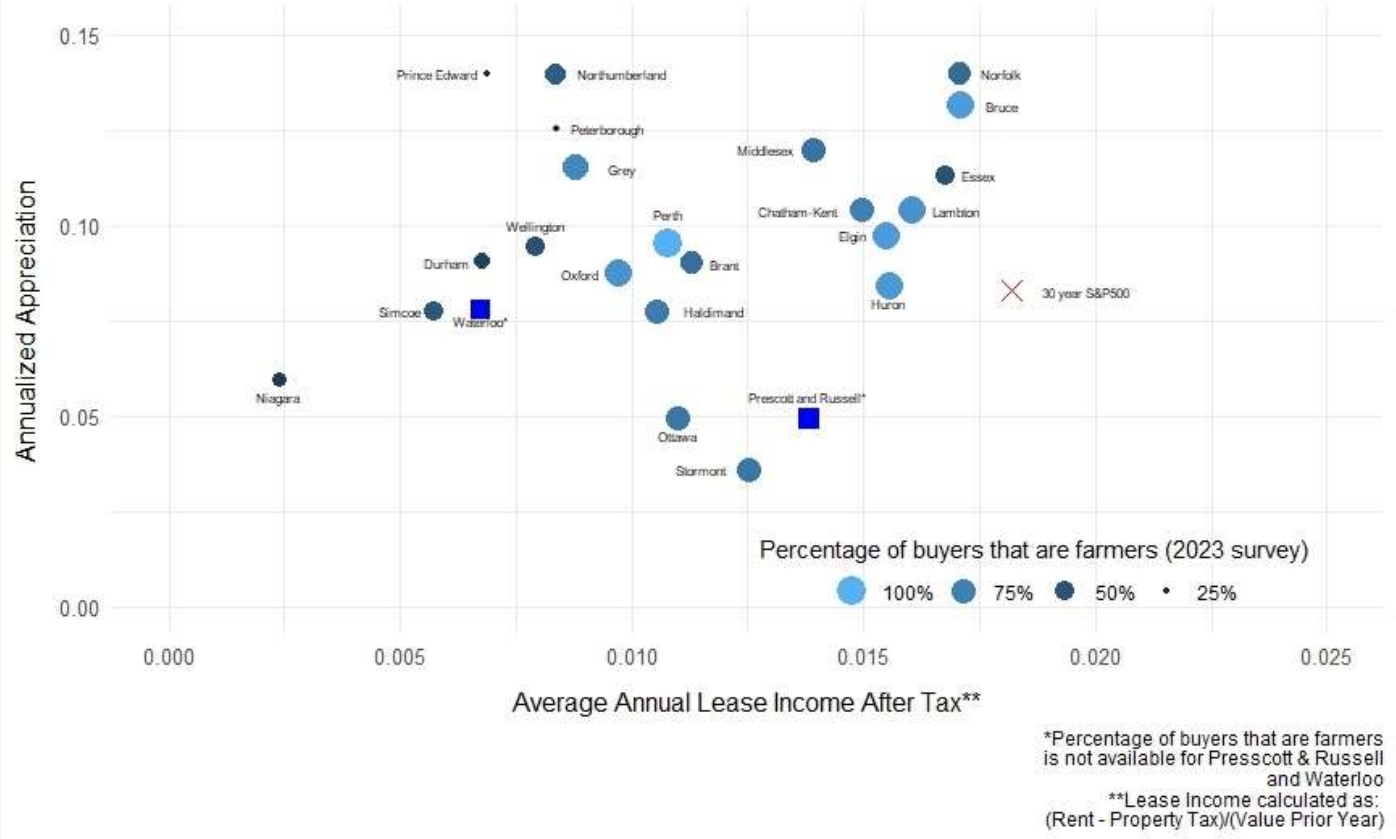

Figure 3. Farmland Appreciation and Lease Income by Southern Ontario County (2016-2023)

When the survey is first introduced in class, students start by exploring the data in the following ways: (1) exploring variation between counties, (2) applying the simple capitalization model, and (3) assessing changes in the survey over time. These points are all discussed above, and students quickly identify many of the aforementioned themes. Importantly, the survey is not introduced in the class until after students have been exposed to the theoretical models, such as the capitalization model and the hedonic property model (Rosen 1974). This way, economic theory can serve as a useful basis for assessing and discussing the survey results.

One exercise we have found useful is to ask students to pick a county that they are familiar with and assess whether they think the rent-to-price ratio is too high, too low, or just right. Many students will choose the county where they are from. For those students who are not from Ontario, we ask them to choose Wellington County, where the University of Guelph is located. While we emphasize that there is no correct answer, students should be prepared to justify their answer using the perpetuity formula or the capitalization model. We are specifically interested in their economic explanation, rather than the "correctness" of their answer. Once the exercise is explained, students are given a short period of time (5–10 minutes) to develop their argument for whether the rent-to-price ratio is too high, too low, or just right. After 5–10 minutes, an in-class discussion begins.

The in-class discussion is the crucial part of this exercise. This discussion gives students the opportunity to present their argument in an informal setting and explain their reasoning. After a student presents their argument, the rest of the class has an opportunity to critique and expand on the initial argument. Students who selected the same county can also join the discussion and argue why they agree or disagree with the student's position. Typically, the discussion begins with a simple analysis of whether

the simple capitalization model (Equation 1) accurately predicts farmland values and rental rates. However, as the discussion unfolds, the class begins exploring topics such as selection of the interest rate, urban effects, personal observations, etc. We also discuss limitations of the survey, and students often make their own suggestions about future survey questions. In this regard, the discussion allows students to begin to think about their own research questions and how they can attempt to answer them.

6 Survey Best Practices

In this final section, we will provide a series of "best practices" for managing an Extension survey such as the OFVRVS. These best practices were developed as a direct result of our learned experiences through managing the survey over the past several years. The primary objective of this section is to provide Extension economists, particularly those early in their career, with suggestions and guidelines for developing and managing similar surveys.

As previously discussed, a key component of the OFVRVS is the farmland study group assembled to help design the survey and assist with outreach. Since the study group includes representatives from Ontario's three farm organizations (the intended outreach targets), the study group provides valuable insights into how to expand the reach and impact of the survey. An important aspect of the study group is that the group meets annually to discuss the previous year survey results and any proposed changes to the upcoming survey. This meeting allows the survey to be continually reviewed and encourages a thoughtful discussion regarding ways it can be improved.

A second aspect of the OFVRVS that has allowed the survey to be successful over the years is the careful attention paid to data management. The survey has its own website (https://www.onfarmlandsurvey.com/) with current and past survey results, as well as an aggregated report. Additionally, all annual reports and a data set containing yearly median prices and rents for each county is securely stored on the Borealis data repository (https://borealisdata.ca/dataset.xhtml?persistentId=doi:10.5683/SP2/HW6LFD). As numerous graduate students and research assistants have worked on the project, processes related to data collection, data cleaning, and report writing are clearly outlined to ensure continuity when individuals transition onto and off the project. This has allowed for consistency between different survey iterations and timely publication releases.

A final element related to the management of the OFVRVS is the considerable emphasis placed on the Extension product. As previous sections have emphasized, a core principle of the OFVRVS is to provide benchmark farmland values and rental rates for Ontario farmers and farmland owners. When considering changes to the survey, this primary purpose is kept in mind to help ensure that the survey continues to provide information that helps inform the decision-making process of its intended users. Extension products and surveys in other regions should regularly reflect on whether their design process and objectives are aligned with the needs of their constituents.

When designing and managing a similar survey in another region, there will certainly be differences and context-specific nuances that are required. These differences are important to consider when designing your own Extension product or survey because they will help create a better Extension product for the target group. The best practices outlined in this section are meant to provide broad themes to consider when designing similar surveys, or even Extension products in general, in other areas. To summarize, the OFVRVS makes it a priority to meet with a farmland study group to discuss the design of the survey, carefully manages data and survey results, and focuses on designing the survey in a way to emphasize the Extension product.

7 Conclusion

The OFVRVS provides landlords, tenants, and other constituents with the ability to benchmark their own observations and better understand the extent to which these accord with key economic considerations. As publicly available information on farmland rental rates in Ontario is scarce, the OFVRVS represents a valuable Extension product to producers, students, and other Extension stakeholders. The examples provided in this article reflect some of the ways we use the survey to enhance outreach and teaching outcomes. Going forward, we hope these examples support an ongoing effort to develop a template for communicating results from farmland value and rental surveys in both teaching and outreach settings.

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Teaching and Educational Commentary

Textbook Review of: Equilibrium Displacement Models: Theory, Applications, and Policy Analysis. By Gary W. Brester, Joseph A. Atwood, and Michael A. Boland

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Abstract

Equilibrium Displacement Models: Theory, Applications, and Policy Analysis by Gary W. Brester, Joseph A. Atwood, and Michael A. Boland provides a resource that serves practitioners and students alike. The discussion of EDMs is scholarly, rigorous, and clear throughout the book and it will be a useful resource for all scholars who are interested in analyzing policy impacts. The book is engaging and effective from a pedagogical point of view and provides clarity of explanation and breadth of policy examples. The review is conducted by a group of applied economists with specialization in EDMs, reflecting many different uses and perspectives.

1 Introduction

Equilibrium Displacement Models: Theory, Applications, and Policy Analysis by Gary W. Brester, Joseph A. Atwood, and Michael A. Boland provides a resource that can be used by practitioners and students to answer policy impact questions. The broad base of the textbook and its appeal to different users prompted us to use a multi-author approach to review the book. The review includes an extensive list of models from the book available online in a Microsoft Excel workbook. In what follows, we provide the reviews of different chapters of the book by applied economists with specialization in equilibrium displacement models (EDMs).

2 Book Review

Chapter 1 provides an overview of EDMs in terms of their widespread use and motivates why the book was written and for whom. The use of EDMs is well known by those who work in policy analysis, and the authors motivate why EDMs, computable general equilibrium models, and simulations might be appropriate in specific situations. Both pros and cons of this partial equilibrium framework are discussed. In addition, general applications to both vertically and horizontally related markets are presented. The chapter concludes with a discussion of using EDMs to estimate changes in producer and consumer surplus caused by exogenous shocks to a market based on a cursory literature review of EDM applications.

Chapter 2, the literature review chapter, is cursory in the sense that many papers using EDMs have been published. The chapter organizes the literature review into various categories, although many studies encompass more than one model. For example, some studies may focus on input markets while also evaluating market interventions. The authors have presented studies that are categorized into such areas as international trade, research and development, advertising, market power, and precision of EDM estimates. What is helpful in this chapter is a discussion on how EDMs evolved over time, which shows why their use was never codified before into one source, such as this textbook.

Chapter 3 explains why EDMs are attractive for studying problems in applied economics. Perhaps more than other partial equilibrium models, EDMs are prized for their simplicity and ease of construction. A key strength of these models is their ability to elucidate market responses without requiring full knowledge of underlying functional representations. This feature makes them particularly versatile. EDMs are well-suited to evaluate the effects of market perturbations within a multifactor framework. For instance, they could be used to measure the impact of fertilizer price shocks on the ethanol industry or evaluate the effects of labor laws on strawberry growers. This chapter gets to the core of what an EDM does—evaluating the effects of economic shocks. While practitioners have many different tools to choose from to tackle this task, the attractiveness of an EDM is its simplicity—it takes our complex, often nonlinear reality and returns linear approximations. The authors dedicate Chapter 3 to demonstrating this through the use of several simple mathematical examples, both with linear and nonlinear equations. These examples provide the reader with the book's first glimpse of an actual EDM (albeit purposefully via a simplistic example); the authors are not demonstrating how to use an EDM in an applied sense, but rather, illustrating both the simplicity of EDMs set against other methods and that the resulting approximations are comparable to those generated by other more complicated and more complex tools. The reader is also provided with some guidance in when (or perhaps when not) to use EDMs. At the conclusion of Chapter 3, one question is still not clear. EDMs are efficient tools for approximation when analyzing relatively small perturbations of parameters but can begin to lose accuracy as the size of perturbations increases. How big of a perturbation is "too big" for a versatile EDM?

Chapter 4 addresses the conversion of the basic primal problem into its dual structure, which is needed due to the uncertainty of the functional form of the production function in an EDM. Chapter 4 and the rest of the text offers a much needed and very useful resource for practitioners. In reading Chapter 4, there were two main areas in need of more emphasis, which can be seen as an opportunity for future expansions of this new resource. First, many EDM applications in the literature involve multiple horizontally connected industries that each contain multiple vertically connected sectors. For instance, consider beef (cow-calf, feedlot, wholesale/packer, and end user), pork (farrow, finish, wholesale/packer, and end user), and broiler/chicken (live animal and end user) applications in the *American Journal of Agricultural Economics* and other key outlets. It remains to be seen exactly how the authors' homogenous of degree zero (HOD0)-consistent approach would apply there. The need for more parameters in an EDM (e.g., cost shares at each level) must be appreciated. Second, some practitioners use EDMs for forward-looking, projection-generating purposes, and it would be nice if a forecasting example could have been included to assist in these applications.

Chapter 5 illustrates how to use EDMs to estimate the impacts of market intervening policies. These policies create differences between consumer and producer prices or quantities demanded and supplied. These differences are incorporated into the model as equilibrium equations. The policy examples are grouped into cases where policies specify the magnitude of the differences (referred to as "exogenous wedges") and cases where policies do not specify the magnitude of the shock ("endogenous wedges"). Additional restriction equations are necessary in the case of endogenous wedges for the model to identify specific values of the shock. Examples are illustrated throughout the chapter, using the one-output, two-input model developed in Chapter 4. The content is figuratively the meat of the book for readers who are interested in applying the EDMs for policy analysis. The policy examples are comprehensive for most food and agricultural applications, particularly pertaining to the United States, and are presented in ways that allow for readers to match their policies of interest to the examples in the chapter, with an ability to adapt them if necessary. This compilation is a valuable contribution. The chapter is organized like a how-to manual. A result of this organization is that the exposition of examples becomes repetitive, but this feature will be helpful to readers who want to jump to and learn about the examples that are applicable to them. This type of reader, however, may need to spend some time finding the most applicable example in the current format of the text. The chapter might have been more helpful

if it had an overview of the policies and how the authors categorized them, along with a list of numbered sub-sections that correspond to the examples with a reference to the page numbers.

The organization of Chapter 5 is less suited to readers seeking a general understanding of applying EDMs for policy analysis. These readers may find the repeated material in the series of examples distracting, while wondering how many examples they need to study to have an adequate understanding of the concepts. If the chapter were to be reorganized for these readers, the mechanism of exogenous and endogenous wedges could be elaborated on and generalized with one specific example for each. Other examples could be deferred to a separate section as practice problems with answers.

Chapter 6 investigates several approaches to incorporating market power into EDMs. Essentially, market power can be considered a tax on a market in which "tax revenue" is obtained by those with market power. Examples include results from monopoly pricing and the use of price ceilings to offset monopoly power. An evaluation of a monopolistically competitive market is also provided. Although relatively few papers have incorporated market power into an EDM, the chapter demonstrates how it can be done in a straightforward manner.

Chapter 7 demonstrates the use of EDMs for examining several policy interventions in markets with multiple inputs or outputs. The functional form of the EDMs are clearly defined and presented in a way that will allow easy adaptation for practitioners. For all presented policy scenarios, the authors clearly define all parametrized variables and their associated values, with references, such that the reader could replicate their results in a general spreadsheet package with ease. The chapter begins by presenting an EDM with two connected markets. The authors present a scenario of international beef trade where there exists an import demand function, export supply function, tied through a total domestic availability function. With import and export shares generated from historical averages and elasticities pulled from the literature, the EDM estimates a wide range of typical international trade policies. With slight modifications to the base model, the presented EDM shows how several impact assessments can be performed, including a tariff placed on imported beef, a change in an existing tariff, export subsidies, or import quantity restrictions.

Chapter 7 also details how an EDM can be used to model a market with three inputs and a single output. After augmenting the basic EDM to include equations for the three-input case, various policy scenarios are considered that demonstrate the flexibility and intuitive appeal of EDMs. The EDM can estimate the impact on equilibrium market prices and quantities associated with an exogenous change in output demand, a restriction of input use, or a change in input cost. The chapter demonstrates these policy interventions for a production function that has both flexible input use and one that has fixed input proportions.

Finally, Chapter 7 presents the idea of specifying one of the inputs in the industry production function as financial capital or owner's equity. In most cases for which government interventions affect a market, there will be implications for the owners of the firms that supply the market and the returns on their investments. By modeling one of the inputs as financial capital, using estimates from the literature for short-run own-price elasticity of the supply of financial capital, and adjusting the substitutability with other inputs in the production process, the EDM can estimate the impact on returns to capital in a market when policy shocks are introduced. Minimum returns to owner's equity are required for an industry to remain competitive. By explicitly modeling these returns, while conducting policy analysis, economists may be able to discuss potential long-run impacts on capital flows in and out of an industry. This may be of particular relevance for an infant industry that relies on outside investment or venture capital such as agricultural technology and innovation.

Chapter 8 addresses issues related to using EDMs to calculate changes in economic surplus and deadweight losses. As noted by Just, Hueth, and Schmitz (2004), care must be taken when using partial equilibrium models to estimate these changes to avoid double counting. Also, changes in surplus are not estimable for some markets included in an EDM if exogenous shocks that emanate from outside the modeling structure are being considered. For example, a shock to the demand for a product may be

caused by a change in the demand for a substitute. However, if the substitute product (and all other substitutes) are not included in the model, it is not possible to calculate a change in consumer surplus because only the demand for one consumer product is being considered. That is, one does not know what the net change in consumer surplus will be in response to a shock in a market not included in the model. The chapter is highly detailed and presents two different ways of calculating changes in consumer and producer surplus caused by market interventions. Authors who wish to measure welfare effects should pay close attention to this chapter.

Chapter 9 notes that EDMs express results in percentage change, and as such a key fact of all EDMs is that they require estimates of structural elasticities (e.g., own price, cross price, output, input, etc.). Because EDMs are effectively linear (first order) approximations in differential space, the elasticities are treated as constants, but we know that in general, elasticities are not constant and can change (for example) in response to induced changes in price or quantity. This leads to a related question: How sensitive are the results for an EDM to the elasticities used to calibrate the model? A standard approach in the literature is to present a table with a range of elasticity values from say 50 percent to 150 percent of baseline values to assess how the results are affected. This approach is useful in identifying which parameters are important drivers of the results and which are not. However, it does not tell us how parameter uncertainty affects inferences. For that, confidence intervals for the simulated price and quantity effects are needed. This need was addressed in separate papers by Davis and Espinoza (1998) in the United States and Zhao et al. (2000) in Australia. These papers showed how confidence intervals for results from EDM can be constructed by replacing the point estimates of elasticities in the model with their probability distributions. The confidence intervals provide a basis for inferring whether simulated price and quantity effects are significant, that is, different from zero in a statistical sense.

In motivating Chapter 9 on sensitivity analysis in EDMs, Brester, Atwood, and Boland emphasize the purpose of adopting a probability distribution approach for sensitivity analysis is "…if a researcher wishes to estimate confidence intervals or perform hypothesis tests, then they must consider joint realizations of an EDM's underlying parameters (Davis and Espinoza 2000)" (Brester, Atwood, and Boland, p. 233). While it is certainly the case that a natural implication of doing, what has succinctly been termed a Stochastic EDM (SEDM) elsewhere (Dharmasena, Davis, and Capps 2014), is the ability to construct confidence intervals and conduct hypothesis tests, that was not the initial motivation. The initial motivation stemmed from a concern about non-signable comparative statics. It is well known that analytically in most systems of equations coming out of economics the comparative statics are not signable. Stated alternatively, in most cases, the exact direction of the effects of exogenous shocks is not known unequivocally. Thus, the actual direction (sign) of the effect of the exogenous shock will depend on the interactions of the relative magnitudes of (i) elasticities and (ii) exogenous shocks. An SEDM is a type of empirical comparative static exercise that would provide information on the most probable sign, magnitude, and significance, which are at the heart of empirical estimation.

Chapter 9 addresses an issue not evaluated in Davis and Espinoza's (1998) study, namely the effect of correlated elasticities on simulation results. Specifically, a copula approach to generating the covariances/correlations among elasticities is taken, and simulations are performed with and without the indicated correlations to determine how results from a simple EDM are affected. In the book, application results were not affected to any extent. Although a nice application of copulas, it should be realized that this is just one approach to getting covariances and is based on non-sample information (assumptions), whereas alternatively if one is pulling elasticities from an econometric analysis, there may be covariances based on data and estimation (i.e., sample information). Chapter 9 and the accompanying appendix is good in terms of walking one through how to do stochastic simulation of an EDM and the use of spreadsheets, which are downloadable. If the reader is not familiar with the conceptual steps (theory) of copulas, they may need to consult the original Iman and Conover (1982)

article or related literature. In sum, Chapter 9 provides a clear and concise introduction and example of the usefulness of adding SEDMs to the applied economist's toolbox.

Chapter 10 provides a summary of the book. This would have been a good place to remind readers that the models and results presented in the book have been developed within Excel, and the spreadsheets are available online from the University of Minnesota Library's website. In addition, a print-on-demand link is available from that website. Two things might improve the book in a later edition but do not detract from this first edition. First, consider expanding the definition of EDM as discussed by Piggott (1992). This would expose the reader to a larger literature on the topic that has proved useful for policy analysis. Two examples by Martin and Anderson (2012) and Kinnucan and Myrland (2005) demonstrate this. The book gives the impression EDM is confined to Muth's model but in reality, Muth-type models are a subset of a larger class of models referred to by trade economists as "hat-calculus models." Second, the book focuses on policy applications of EDMs. However, they have another useful function, namely providing a theoretical basis for specifying econometric models and interpreting their results.

3 Conclusion

Brester, Atwood, and Boland are to be thanked for bringing together in one place a presentation of one of the main tools in the applied economist's toolbox, the EDM. Prior to this book, the researcher and student interested in learning about EDMs would have to scour the literature searching for descriptions of the tool and various applications. The book is full of much useful information related to the underlying theory, implementation, and interpretation of EDMs.

The discussion of EDMs is scholarly, rigorous, and clear throughout the book. The preface and emails add a personal touch that draws the reader in and adds to the book's effectiveness from a pedagogical point of view. The book is a must-read for anyone interested in using the method in their research or teaching. To be sure, there is no way to fully meet the needs of all readers, and any shortcomings of the book are outweighed by its clarity of explanation and breadth of policy examples. It will be a useful resource for all scholars including upper-level undergraduate and beginning graduate students who are interested in analyzing policy impacts with an EDM. The authors should be commended for a text that is easy to follow, which, in turn, will notably increase the impact of this resource for years to come.

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Teaching and Educational Commentary

Reflecting on Using Reflection Exercises to Improve Student Learning and Teaching Effectiveness

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JEL Codes: A22; A20
Keywords: Experiential learning, Reflective learning, Teaching effectiveness

Abstract
In this commentary, I reflect on employing reflection exercises to improve student learning and teaching effectiveness. The theory of reflective learning and the importance of engaging in reflection after active and experiential learning are discussed. I present on overview of the reflection exercises that I employ, which are based on the Respond, Summarize, Vocabulary, Pose a New Question (RSVP) method and Gibbs' reflective cycle. Reflection assignments allow students to document their learning experience while also providing feedback used to make improvements to the course in real time. The summaries and questions posed by students assist with the identification of topics and concepts that need to be reviewed and remediated. Employing these exercises have increased students' class attendance, engagement, immediacy, and average course grades as well as my rapport with students and scores on my formal end-of-term course evaluations. Students' suggestions have led to the deletion of old assignments, creation of new assignments and reorganization of the course material, improving course effectiveness. Students indicate benefiting from engaging in the reflection exercises by feeling more connected to the course material. Students also demonstrate a deeper understanding of the course material.

1 Introduction

For nearly a decade, I struggled to achieve the same outstanding course evaluations for Advanced Agribusiness Management that seemed to come so easily for the other courses that I taught. No matter what I tried, the scores on these course evaluations consistently fell below my scores for other courses by almost 1 point on a 5-point scale. This changed when I started employing a series of reflection exercises.

Advance Agribusiness Management is a required capstone course for the Food and Agribusiness Marketing and Management specialization within Food and Resource Economics (FRE). Seniors enrolled in the course actively co-manage a company in teams of 3–5 through a semester-long online simulation. While the course focuses heavily on the application of financial concepts, the simulation requires students to also utilize skills learned in several prior courses including marketing and management. Students apply these concepts to complete a series of assignments and assessments based on the simulation. These include weekly assignments in which students must justify the decisions they made and two presentations to the Board of Directors (BOD), consisting of the teaching assistant, other FRE faculty members, and me. The BOD presentations are essentially oral exams in which students are asked to defend their managerial decisions in the simulation using their knowledge of finance, marketing, and management. Students also complete three individual case study assignments that help them develop a better understanding of the key concepts taught in the course before applying them to the simulation. The course consists of lectures and numerous hands-on, active-learning, and peer-teaching exercises such as in-class games and group assignments. The course is designed to engage students in active and experiential learning to encourage creative and critical thinking and the development of advanced

financial management skills through application. Ultimately, the goal is for students to develop skills that they will utilize in their chosen careers.

In Fall 2020, after seeing a presentation at the College of Agriculture and Life Sciences (CALS) Teaching Enhancement Symposium on reflection exercises (Emmanuel 2020), I decided to give it a try. Honestly, at the time, the decision to experiment with a reflection exercise was not motivated by the desire to improve my teaching but to simply get through the semester. I was expecting my second child due in mid-December, and I had what proved to be an accurate premonition that I would not make it to the end of the semester. Thus, I assigned a reflection video exercise to replace the typical second set of BOD presentations, knowing that I could easily watch the videos while caring for a newborn. What I did not anticipate was the insightfulness of the feedback that I received from students.

I now require students in all of the courses that I teach to complete weekly reflection journals based on Gibbs' (1988) reflective cycle and the Respond, Summarize, Vocabulary, Pose a New Question (RSVP) method (Emmanuel 2020). These assignments allow students to document their learning experience and self-assess their progress while also providing feedback, which I employ to make improvements to the course in real time. In addition to the weekly journals, I require students in Advance Agribusiness Management to submit a reflection video at the end of the semester. These videos are more holistic assessments of students' impressions of the course and suggestions for improvement. The suggestions contained in these videos are generally much more detailed and actionable than what is typically found in standard course evaluations.

2 Theory of Reflective Learning

The journal exercises are based on the theory of reflective learning. While there are many different models of reflective learning, Boud's triangular representation (Figure 1) is perhaps the simplest (OpenLearn; Boud, Keogh, and Walker 1985). In this model, engaging in reflection after engaging in experiential learning leads to further learning. It is similar to Kolb's (1984) learning cycle that involves four stages: concrete learning, reflective observation, abstract conceptualization, and active experimentation. In both of these models, reflection after experiential learning helps to solidify knowledge and leads to additional learning. Over time, these models have been extended to provide more detail. For example, Gibbs' (1988) more complex reflective cycle is presented in Figure 2.

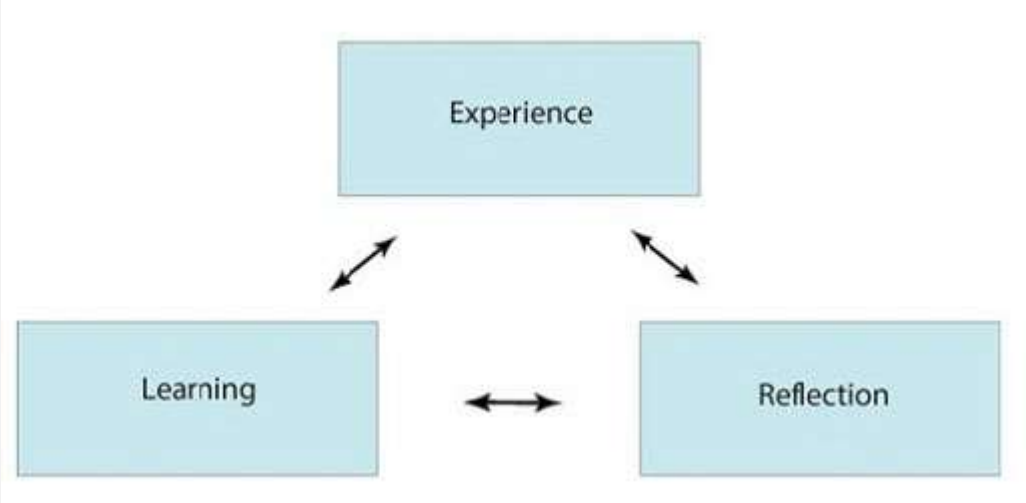

Figure 1: Boud's Triangle.

Source: OpenLearn, n.d.

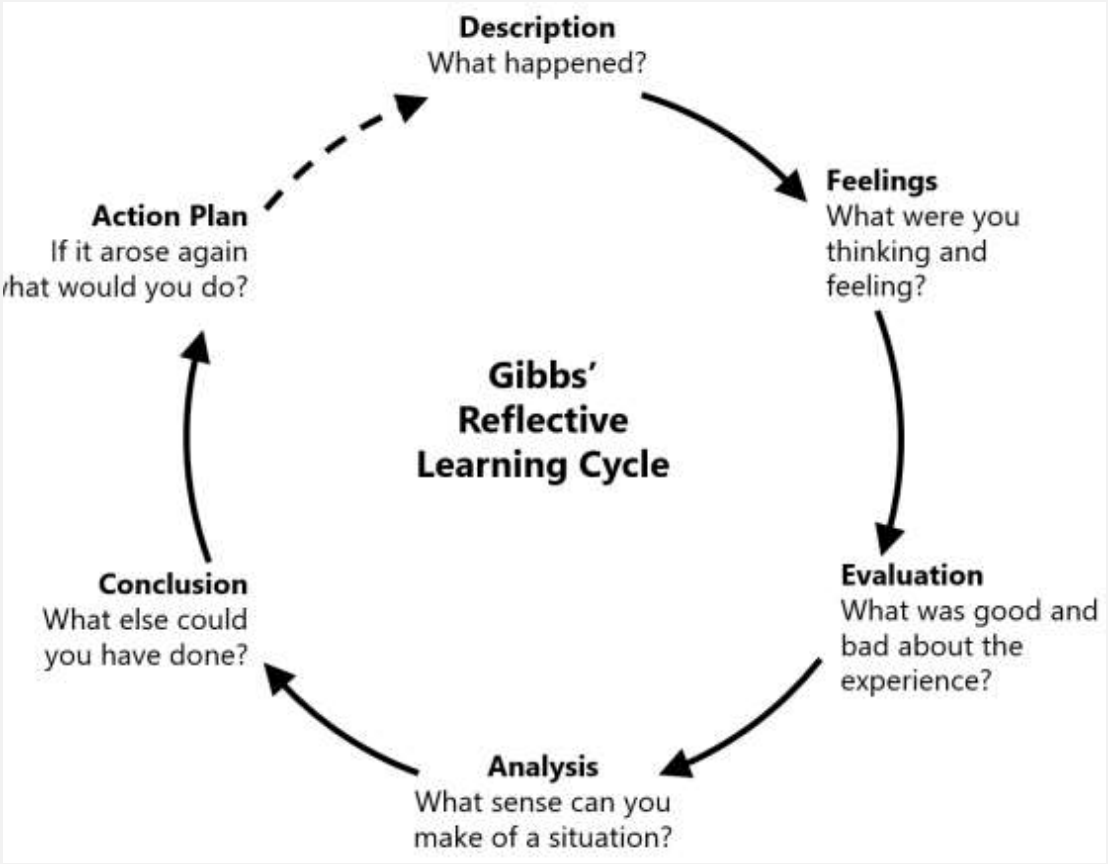

Figure 2: Gibbs' Model.

Source: Gibbs 1988; Mohd Harithuddin 2021

A variety of strategies can be employed to encourage reflection. These include written or oral form and group or individual exercises. Clemson University (n.d.) and the University of Tennessee Knoxville (n.d.) provide excellent summaries of various reflection activities. Eyler, Giles, and Schmiede (1996) outline four core principles that effective reflection strategies share, known as the four Cs: continuous, connected, challenging, and contextualized. Continuous indicates that reflection must be woven into the entire course for it to be effective; it cannot be a one-off activity. Connected requires that the reflection process must enable students to make connections between their academic learning and experiential learning. Challenging indicates the reflection process must prompt students to reflect more deeply and even question their pre-existing knowledge and assumptions. Contextualized ensures that the reflections are relevant and meaningful to the students' experiences. Eyler and Giles (1999) add coaching as a fifth C to emphasize the importance of instructor feedback and guidance throughout the reflection process.

Effective reflection also employs the four Fs: facts, feelings, findings, and future (Greenaway n.d.). Facts provide an objective account of what happened, while feelings summarize the emotional reaction. Findings summarize the concrete learning from the situation, and future encourages reflection on how the knowledge gained can be employed in future situations. Elements of all four Fs can be observed in the Gibbs' reflective cycle (Figure 2); hence, it the basis for the reflection exercises that I employ.

3 Reflection Exercises

Each week students are asked to take a few minutes to reflect on what they have learned using the RSVP process developed by Meghan Kahn at Indiana University and modified by Amber Emanuel at the

University of Florida (Emanuel 2020). Students are asked to reflect on each activity, assignment, and lecture. Figure 2 is included in the assignment instructions, and I ask students to consider the questions as they prepare their weekly journal entries in the RSVP format. Specifically, students are asked to:

1. Respond: What was your reaction to the information presented? What did you learn/what was new? What was hard to understand? What part(s) of the assignment frustrated you?

2. Summarize: Summarize in *your own words* the key concept(s). Your summary should be several sentences long and provide an overview of the key points and main takeaways, and how these concepts are linked to prior course concepts.

3. Vocabulary: Write out and define one word that was new to you.

4. Pose a New Question: Write one question that you have that needs further clarification or a follow-up to something you learned or want to know more about.

Students submit their journal entries each week via the course management website (Canvas). The journal entries are graded based on completeness and thoroughness in following the RSVP format for each lecture and activity.

As a final course assessment, students must submit a video (no more than 10 minutes in length) in which they discuss their big ah-ha moments in the course. Students are also asked to discuss how the key concepts fit together, how these concepts are employed in financial management, and how they plan to use the skills they developed in the course in their intended career. Students are instructed to discuss specific course activities and explain how these activities helped them learn the concepts. Students are asked to discuss the barriers to the learning process that they encountered and what they would do differently if they had to do it over. In addition, students are asked to discuss what I could have done differently to improve the learning experience and suggest improvements for future iterations of the course.

4 Reflecting on Reflection

Since implementing these reflection exercises, I have observed several benefits to the activities, including improved student engagement and end-of-term course evaluation scores. First and foremost, the summaries and questions posed by students in the journal entries allow me to identify topics that need to be reviewed and remediated. Each week, I read the journal entries prior to preparing the week's lecture material and assignments. I do my best to address each question either individually using the grading comment function in Canvas or by discussing it in class. Hearing other students' questions encourages students to ask more thoughtful questions and encourages them to provide a more honest assessment of their understanding of the material in the Respond section of the assignment.

Furthermore, responding to individual students' questions helps to build rapport with the students and immediacy. As a result, attendance and engagement has increased (and it is certainly more fun to teach when the students are engaged). I have had students apologize for their poor performance on assignments, taking responsibility for not allocating the appropriate amount of time to completing them. Prior to implementing the reflection journals, students would often complain about the amount of work required; by reflecting on each assignment, students now understand how each assignment contributes to their learning and links with the course material. Prior to implementing the reflection exercises, the average course grade was a B-, now the average grade is a high B+. Because of the rapport developed through the journals, students feel more comfortable stating criticism and offering suggestions for improvement. When feasible, I try to implement students' suggestions within the current

semester. This helps to maintain student engagement with the process. In addition, the rapport that I develop through the journals makes students feel more comfortable sharing their own challenges. I have connected students with mental health, victim advocacy, domestic violence, and addiction services because of what they shared in their journals.

Implementing students' suggestions have made the course more effective. Students' suggestions have led to the deletion of old assignments, creation of new assignments, and reorganization of the course material. I tailor the pacing of the course and depth of material based on students' feedback and interests each semester. Customizing the course to the students' needs further promotes engagement.

In addition to improving the course and my teaching, students also indicate benefiting from engaging in the reflection exercises. Students indicate feeling more connected to the course material by being "forced to review it each week." Prior students have also found their journals to be a helpful study tool. Thus, I now encourage students to compile all journal entries in one word document that can easily be searched when studying. The answers that students provide during the BOD presentation confirm that students have a deeper understanding of the material. In the reflection videos at the end of the semester, students often comment on how preparing the video helped them appreciate how much they learned in the course. They frequently indicate feeling "proud" and "accomplished." They provide clear examples of how they intend to use the material in their intended careers and hence the students view the course as more valuable. Students often indicate that they highlight course activities in job interviews, and most students graduate with jobs.

While there are many benefits of implementing these reflection exercises, there can be some challenges as well. It often takes several weeks for students to fully engage with the process. At the beginning of each semester, students often feel writing the journal entries is "busy work" as they do not yet appreciate the value. In addition, thoroughly responding to each student's question individually is time consuming. It takes me about 2–5 minutes per entry to read and respond. As the students' questions become more complex over the course of the semester, the time required to respond increases. While a teaching assistant may be able to assist in larger classes, they may not have the knowledge to understand nuances in students' summaries or to respond to more complex questions. Artificial intelligence programs could be employed to assist as well, particularly as natural language processing and large language models continue to improve. But ultimately, other reflection activities may be more suitable for large classes. I have also found that graduate students tend to write rather lengthy summaries; as a result, I now put a 100-word cap on the summary section. In spite of these challenges, in my opinion, the upside of employing reflection exercises clearly outweighs the downside.

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Teaching and Educational Commentary

Innovate to Lead: Curriculum Innovations to Meet Students' Needs in Applied Agricultural Economics and Agribusiness Programs

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JEL Codes: A20, A22, A23, O3, Q00
Keywords: Curriculum, global, higher education, innovation

Abstract
Applied Agricultural Economics and Agribusiness programs aim to equip graduates with decision-making and problem-solving skills for a globally competitive and dynamic business environment. Ensuring student success requires instructors to explore innovative curriculum formats that augment the learning of theoretical concepts, while promoting students' preparedness for future careers. In this commentary, we highlight three categories of innovative curriculum ideas and present evidence from corresponding student feedback and instructor experiences. We begin with examples of distinctively designed single-hour credit offerings that intend to enhance student learning of the subject matter and business applications while offering professional development opportunities. We further describe programs and courses constructed to enhance global awareness and exposure for students, citing experiences from study abroad programs and from courses employing the Collaborative Online International Learning (COIL) model. The third category uniquely identifies courses with opportunities for incorporating industry sponsorship in classroom projects, and ideas to shift graduate thesis projects toward writing industry-focused case studies.

1 Introduction and Motivation

Today's higher education institutions are tasked with meeting challenges of unprecedented demographic and enrollment cliffs. These cliffs refer to a predicted drop in the college-age population soon due to lower birth rates and other demographic shifts (Getman 2024). Finding implementable solutions to these challenges (posed by these cliffs) is key to the sustainability and growth of academic programs, colleges, and universities alike. Operating in a dynamic environment, administrators and academic programs will need to reformulate their strategic plans, while closely monitoring the shift in student expectations as they deal with impending demographic and enrollment cliffs. These strategic plans will vary based on the region, type of institution, and population they serve.

It is important to understand that these cliffs, characterized by changing demographic trends and a steep fall in college enrollments,[2] cannot solely be attributed to a shrinking traditional college-age population because of declining birthrates. Reduced state funding for public higher education, steeply rising tuition, immigration changes, a decline in the international student population, negative

[1] Rachna Tewari and Na Zuo are leading authors, with Rachna Tewari as corresponding author. Other co-authors are listed alphabetically based on last names.

[2] Grawe (2018) presents evidence on forecasted growth and decline in college-going students for the period 2012–2029. He predicts a decrease of 11 percent nationwide, but significant variation exists among regions with Northeast and Midwest states facing higher declines, and California and Northwest states seeing an increase. Moreover, there is a distinct difference between regional and elite institutions, with the former expected to see a decline and the later an increase.

pandemic-induced economic effects, and a growing public skepticism of the net economic benefits of a college education, all significantly contribute to enrollment and demographic cliffs (Downs 2023). Moreover, we cannot discount the effect of strong labor markets with people opting to forego college for the workplace.[3]

The emerging buyer's market for higher education calls for a rethink and redesign of academic programs, making programs and degrees innovative, attractive, valuable, and adaptable to student needs and expectations. From a student perspective, affordability and career preparedness are the top factors influencing students' choice of a post-secondary degree (National Student Clearinghouse 2022). These factors further emphasize that future students will continue to prioritize career-specific programs that are relevant to them and that fit their personal and professional goals.

From an academic program and faculty perspective, innovation in course formats and design could help meet changing student expectations and make the college experience more meaningful, rewarding, and personalized, while enhancing student engagement and learning (Mintz 2021). Anselmo et al. (2023) summarize three innovative course designs that can be adapted to fit blended, face-to-face, or online courses: (1) backward course design, based on the premise of logically inferring courses from the learning goals, rather than the approaches or techniques that are convenient for the instructor (Bowen 2017); (2) inclusive course design, promoting a culture of global engagement, sensitivity, and awareness among students by incorporating approaches built on inclusion and understanding of diverse outlooks, individualities, and experiences of people (Richler 2015; Fuentes, Zelaya, and Madsen 2021); and (3) Learner-centered course design consisting of three sequential steps—establishing student learning outcomes, determining assessments for the learning outcomes, and developing the most effective teaching-learning methods to assist students achieve the outcomes (Huba and Freed 2000; Weimar 2013).

This commentary examines three innovative curriculum ideas within Applied Agricultural Economics and Agribusiness (AAE&A) programs based on the designs discussed above that complement and augment the learning of theoretical concepts, while promoting students' preparedness for future careers.[4] We first explore the effects of focused one-hour credit courses, labs, and quiz bowl practice sessions. These initiatives deepen understanding of the subject and its business applications, offering valuable professional development opportunities. We then delve into courses designed to enrich global experiences, such as a unique semester-long study abroad program and a course applying the Collaborative Online International Learning (COIL) model. The commentary further explores the use of industry sponsorship in classroom projects and ideas to shift graduate thesis projects toward writing industry-focused case studies. Finally, we conclude with a reflection on potential innovative ideas and a discussion of challenges for the future.

2 Adapting Single-Credit-Hour Courses

Early literature on single-credit hour courses derives primarily from STEM disciplines (Pierre et al. 2009) for laboratory-based courses or courses designed to meet program and accreditation requirements. Studies have highlighted benefits such as enhancing co-teaching experiences (Ricker 1997), providing alternatives to three-credit-hour courses (Deans 2017), introducing industry liaisons and career paths (Folsom et al. 2004; Bhandari et al. 2013; Bilder 2022), and exploring internships and professional accreditations (Bilder 2022). Moreover, single-credit hour courses can enhance upper-level

[3] Yet, such change may differ as certain career paths have specific education requirements (for example licensure requirements conferred through a college degree, see certified accounting).

[4] This article was inspired by the discussion and feedback received by presenters at the track session "Innovative Course Formats to Enhance Student Learning in the Applied Agricultural Economics and Agribusiness (AAE&A) Programs" sponsored by the Teaching, Learning, and Communications (TLC) and Agribusiness Economics and Management (AEM) sections at the 2023 AAEA Annual Meeting.

skills through research seminars (Chiu et al. 2020) and offer training opportunities in course instruction for graduate students (Zuo, Penn, and Asgari 2018). Single-credit-hour courses in AAE&A programs aim to add value to student experiences, link curricular with hands-on experiences, and enhance soft skills. Below we present examples of single-credit-hour courses designed as stand-alone courses, and team or co-taught courses.

2.1 Single-Credit Stand-Alone Courses

2.1.1 Quiz Bowl Class

The "Competition Practicum in Ag Economics Terminology" course at Louisiana State University is designed for freshmen or transfer agribusiness students to familiarize them with the jargon of AAE&A. Each week, 30 new terms are introduced from other courses often required of agribusiness students, with a brief, non-technical review of each word. The primary innovation is its use of Jeopardy as a platform to learn and reinforce the material. Each student is expected to play in one round of Jeopardy-style trivia focused on the terms. It embraces entertainment and competition as a means of facilitating learning. While the focus of each Jeopardy round is on the 30 new terms, previous terms continue to appear, reinforcing and connecting concepts from earlier in the semester. In total, students gain exposure to 300 terms over the course of the semester. Students readily recognize and enjoy the novelty of the class format. They also appreciate its usefulness in preparing for other classes. The course is highly structured in terms of its schedule and material, reducing uncertainty for undergraduates. The class lends itself well as the first teaching experience for graduate students, giving them a more manageable first experience as an instructor of record to organize and execute the class's weekly deliverables. Another benefit is professional development opportunities for both undergraduate and graduate students when participating in regional or national events. One potential challenge is that the class requires a working knowledge of numerous topics (microeconomics, macroeconomics, natural resources, finance, accounting, marketing, and management), which may be challenging for narrowly focused or new instructors; however, the course design can be adapted to facilitate non-subject experts. The course's typical format restricts the class to be in-person and of limited size (<25). However, the reliability of real-time technologies enables the course to be taught online synchronously to any number of students.

2.1.2 Topics in Agricultural Labor Class

The "Topics in Agricultural Labor" single-credit course at Louisiana State University is an elective for students in the Agricultural Economics and Agribusiness department. The course is offered at the freshman/sophomore level and is meant to create flexibility in the curriculum, while exposing students to topics not offered traditionally as part of the undergraduate curriculum. Specifically, the course is part of a cohort of single-credit courses, which include "Competitive Practicum" (offered every fall semester), "Visual Data in Agribusiness" (offered every fall semester), "Agricultural Policy Design," and "Topics in Agricultural Labor" (offered every other year). Taught once a week, the course has three distinct components: introduction to theory and why it matters, data analysis, and application. In each module, students are exposed to a single concept (e.g., production function, supply, demand) through a labor prism, easing students into microeconomics, a course that is offered at the junior (3000) level. Students are asked to comment on the model and its feasibility. Then, they are guided to identify data that could help test the theory related to the labor question being examined about the United States and the world. Data analysis tasks include cleansing and structuring data into a useable format and related data visualizations. Last, students are given a policy question to discuss based on the topic covered in the module. Students are evaluated on critical-thinking and information-synthesizing abilities and assessed through a term paper assignment. Throughout the course, students work on polishing their technical writing, critical thinking, and presentation skills. The course's format lends itself to be used for

introducing students to several topic areas in AAE&A programs either as a special topics course or as a stand-alone course.

2.1.3 Workshop Class on Excel Applications

The one-credit workshop course "Excel Applications for Economic Analysis" at The University of Arizona is designed to help freshman and sophomore students develop basic Excel skills to (1) present an issue with data, graphs, and charts effectively; and (2) confidently interpret and use descriptive statistics encountered everyday as well as in their upper-division classes. The instructor weaves together three design elements in the course design: (1) agricultural economics topics, such as farm incomes, food consumer behavior, and food price volatility, to provide context for data analyses; (2) descriptive statistical concepts, including measures of central tendency, shape, dispersion, distribution, and associated relations; and (3) Excel functionalities and skills practiced with authentic data sets from agencies such as the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) and Economics Research Service (ERS), or Willingness To Pay (WTP) survey data from authentic research projects. Students meet 100 minutes per week for eight weeks in a computer lab with hands-on practices. All three design elements are developed and intertwined in the weekly Excel workbooks. For example, students explore food price volatility using the Quarterly Food-at-Home Price Database from the USDA ERS, and practice Excel functions and charts on measures of dispersion. Weekly, the class works through one Excel workbook with multiple worksheets. Throughout the semester, students also complete one individual class project consisting of a two-page fact sheet. Students decide on their specific topic, search for data, and present statistics, graphs, and charts analyzed with Excel. The course has been offered in two institutions with two modalities, in-person labs and as an asynchronous online course. Students appreciate the hands-on learning in the course and have applied the Excel skills in their internships. Students reflected "I liked that we learned how to use some of the many powerful tools and formulae that Excel has in order to analyze and synthesize data in a shorter amount of time and in a well organized format" (Student Course Survey, Spring 2022). "Going into the class, I wasn't very excited because it was a 1-unit class that was only available on Friday morning. I also felt like I already knew enough about Excel and was honestly sad that I had to take it… In the end though, … almost everything I did in Excel in XXX [student's internship company] was something I learned from that class" (Student Internship Report, Fall 2023).[5]

2.2. Single-Credit Labs to Complement Core Agribusiness Courses

2.2.1 Team-Taught Lab to Complement an Introductory Agribusiness Course

A one-hour course titled "Introduction to Agricultural Business Laboratory" was developed at the University of Tennessee at Martin to improve new students' understanding of courses taught within the agricultural business major. The major is contained within a comprehensive agricultural sciences department at the University of Tennessee at Martin, and non-majors taking the introductory agribusiness lecture have indicated their negative experience due to the quantitative components of the course. By creating a supplemental lab course, faculty could preview agribusiness mathematics and Microsoft Excel topics that are explored in future agribusiness courses, while providing a broader and more introductory-level experience for non-majors. Using a team-teaching approach, the agribusiness faculty interacted with students in their initial semesters to aid retention, while building excitement for the agribusiness major. After the first year of offering the course, faculty learned that teaching two to three weeks at a time contributed to student difficulties in getting comfortable with a particular faculty member's teaching style. Differences in student learning styles relative to the way faculty delivered content also contributed to students' abilities to exhibit competency in the lab content. In the initial

[5]Usage of the student quote has been reviewed and approved by IRB with the Protocol Number 1904566916.

offering of the laboratory course, half the students self-identified as kinesthetic learners, 42 percent as visual learners, and the remaining as auditory learners.

The faculty waited until the second year to make significant changes to the course based on data from a full year's worth of course evaluations. Student comments were split on the effectiveness of the lab being team-taught. The difference in teaching styles by faculty resulted in some students having difficulty grasping course content, while others enjoyed the rotation of faculty and thought it kept the classroom experience interesting. To provide more kinesthetic learning opportunities in the second year, hands-on and team-based learning activities were added (e.g., the inclusion of classroom games and guided applications). Changes were also added in the costs analysis section to involve students in actual applications of those concepts in real firm-level decision-making processes. Students participated in activities that improved understanding of agribusiness supply chains, improved negotiation skills, and the economics of production. Core economic and financial management concepts such as financial calculations, elasticities, value-chain dynamics, and basic Excel skills remain in the course content; however, delivery modes have been modified to accommodate students' dominant learning styles. It is also noteworthy that team-teaching may pose challenges for class coordination, course structure, and cohesion in content delivery that would typically not be encountered in courses with a single instructor. Last, an opportunity that the lab provided was involving undergraduate teaching assistants in the lab meetings to assist with content delivery and kinesthetic activities, tracking attendance and class participation, and office hours to help with assigned homework.

2.2.2 One-Credit Lab as a Co-Requisite to an Upper-Level Core Agribusiness Course

The "Advanced Farm and Ranch Management Lab" at the University of Tennessee at Martin is an additional one-credit co-requisite to the traditional three-credit "Advanced Farm and Ranch Management" course. Taught once a week, the lab complement of the course provides opportunities for practical application of learned concepts through hands-on problem solving, interactive assignments, planned farm visits, and developing simulation and linear program optimal solutions for farm management decision analysis problems. The use of Microsoft Excel to develop enterprise budgets, cash flows, financial statements, and linear programming allows an opportunity for the students to further their understanding and improve their data analysis skills. The lab exercises are structured for the students to work through a sample problem with the instructor during the first half of the lab, and then complete a practice exercise on their own during the remainder of the lab session. The instructor assists the students with the practice problem as required and ensures that they check their work for accuracy before submission. This allows for an interactive laboratory environment focused on student effort to learn the concept without the stress of a formal testing process.

The problems from the lab exercises are incorporated in the quantitative assessment of the standard three-credit-hour course; however, the lab grade is independent of the course and is derived primarily from participation and completion of the lab exercises. The farm visit assignments are intentionally designed for the students to learn the economic applications of production practices for crops and livestock at various points in a production cycle. Assessment comprises a whole-farm analysis group project involving the practical application of learned concepts and tools within a farm setting. Student feedback indicates an overall positive hands-on learning experience in the lab as an application to classroom lectures, specifically regarding the management and ownership operation of a family farm. Financial evaluation, cash flows, lease agreements, depreciation, and budgeting exercises were perceived to be the most useful by students as they worked through developing a whole-farm management plan.

3 Innovation with Global Experiences

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) coined the term "global citizenship education" (GCED) in 2011, aiming to enable active, well-informed, reflective, and responsible participation in global society (Global Citizenship Education 2019). With the expansion of digital technology, international travel and migration, and global economy integration, GCED entails the internationalization of higher education with the intentional process of integrating an international, intercultural, and global dimension into the teaching and learning functions of a university or college (Knight 1994; de Wit and Leask 2015). Many Higher Education Institutions (HEIs) around the world have practiced GCED to train graduates as "global-ready" with intercultural competence to address issues associated with global developments and challenges (Deardorff and Jones 2012; Van Gaalen and Gielesen 2014; de Wit and Leask 2015). The dominant strategy to support intercultural competence development is offering students the opportunity to study abroad at an international partner university or do an international internship abroad during their studies (de Wit and Hunter 2015). International travel experiences impact students in many ways, including relational, cognitive, and professional development (Tanikawa 2023). Student participants typically demonstrate better cultural understanding and willingness to move beyond their comfort zone. These can be viewed as prized traits among potential employers. A COIL model has been pioneered by the State University of New York (SUNY) and applied to universities worldwide. The COIL model fosters intercultural competence through virtually connected courses in different universities from different countries. Empirical studies on the COIL approach are scarce. Hackett et al. (2023) used a quasi-experiment of 108 undergraduate students from the Netherlands and the United States (U.S.), and showed a significant increase in intercultural competence for the U.S. treatment group but not for the Netherlands students.

3.1. A Semester Abroad Program: The University of Tennessee at Martin–Agriculture Experience in Sienna, Italy

Universities can use travel experiences to help equip students with cross-cultural competencies to fill in skill gaps that can only be taught by experience. The University of Tennessee at Martin–*Agriculture Experience in Sienna, Italy,* is a semester-long agriculture study abroad program developed by the University of Tennessee at Martin in the Fall of 2021 in partnership with two international institutions. The program was built around cultural experiences, agriculture in the region, and academic courses taught by university faculty. Students were accompanied by university faculty members who taught classes and served as mentors throughout the process. Students and parents appreciated that faculty members from the university were with the students throughout the experience. Faculty also further contributed to this unique experience by modifying the coursework to more closely reflect the culture and demographics of Italy, which added an additional perk to the cross-cultural competencies of this experience. This arrangement did require increased logistical steps to cover faculty duties while faculty were abroad.

The key to any international experience is the planning and partnerships. Once an in-country partner was identified, it required developing agreements and trust among partners. This was accomplished by sending a small delegation, including the University of Tennessee at Martin's Chancellor, to Italy and hosting Italian partners on campus. This was invaluable to the planning and success of the program and allowed for buy-in among all involved parties. After four semesters of travel, these partnerships continue to grow and expand to new opportunities for students and faculty to experience. The program has continued to grow and has expanded to include spring and summer experiences, and the faculty rotation and teaching schedule has continued to evolve to fit student and program needs.

3.2. An Eight-Week Collaborative Online International Learning (COIL) Module

COIL is a virtual model that fosters intercultural competency by linking university classes in different countries. Instruction design and student learning are collaborative in COIL. Instructors in two or three universities in different countries collaborate to create or redesign COIL content for the institution's curricular program. Students remain in their own university but are connected either synchronously or asynchronously online and develop international collaborative projects as part of their class learning. The term COIL was coined by SUNY in 2006 and has become a popular tool to enhance international, intercultural, and global dimensions in the curricula within universities across the world (Rubin 2017). While the high costs have limited the study abroad opportunities to only a small minority of students, for example, 10–13 percent on average in Europe and the United States (NAFSA 2018; European Commission 2020; Institute for International Education 2020), the COIL model provides an affordable way to facilitate intercultural learning and prepare students to work in a global context.

An eight-week COIL module with the theme of "Food, Business, and You" has been developed and offered at the University of Arizona in the United States and Universidad De Monterrey in Mexico since 2022. Through a selective matching process, the two instructors of two classes from the United States and Mexico were paired up in Spring 2022. In June and July 2022, the instruction team—two instructors with an educational researcher at the University of Arizona—developed the COIL module through the Program for the Internationalization of the Curricula United States-Mexico (PIC US-MX), organized by the Mexican Association for International Education (AMPEI), the Embassy of the United States in Mexico, and Banco Santander.

In the eight-week COIL module, students in both classes would connect synchronously for 75 minutes weekly via Zoom. Students were also grouped into six multicultural teams to collaborate on an infographic presentation regarding one grand food challenge picked by each team. Three of the eight synchronous sessions are instructor or speaker-led, including two co-teaching lectures offered by two instructors and one binational panel discussion with industry leaders and stakeholders on the topic of the "Post-Pandemic Food Supply Chain." Another four COIL synchronous sessions are student-led and include a community-building session, two collaborative teamwork sessions, and team project presentations. The last week of COIL learning was delegated for reflection.

The COIL module has been offered twice in the Fall semesters of 2022 and 2023. The primary pre- and post-assessment with the Fall 2022 class showed increased knowledge, skills, and attitudes toward intercultural competency, though the differences were not statistically significant. This finding is unsurprising given eight weeks is a short period of time, especially with the virtual experience. As one student put it in the reflection:

> *"It might not have been as intensive as a face-to-face exchange, had we done COIL, say as a conference or as part of a holiday program, but nevertheless, I felt like my learning in the class could be discussed, applied, and shared with our peers in Mexico. A great example of this was the infographics produced by our group."*

In addition, COIL has provided students with opportunities to practice exchanging views on various ideas, beliefs, and knowledge with international peers, which is crucial to GCED. One student commented on the impact: "A lot of this [COIL] learning wasn't even related to food economy issues, but rather larger concepts like worldviews, beliefs and so on."

4 Innovation with Industry Experiences and Sponsorships

Connections between universities and industries, and the corresponding impacts of such partnerships on innovation processes have been widely examined across disciplines and areas such as management studies, the economics of innovation, industrial organization, and the sociology of science and science

studies (Agrawal 2001; Organisation for Economic Co-operation Development 2002; Poyago-Theotoky, Beath, and Siegel 2002; McMillan and Hamilton 2003; Hall 2004). Partnership opportunities can emphasize areas of experiential learning, authentic learning, or project-based learning, and can be instrumental in filling gaps found through assessment of student learning. In applied pedagogy, particularly within the agricultural sector, fostering innovation and entrepreneurship among students presents a compelling challenge. A proactive approach to this challenge involves integrating real-world industry collaboration within academic curricula. The following section specifically discusses innovation via industry sponsorships and using a case-study-based research option for a graduate thesis.

4.1 Creating Applied Classroom Projects with Industry Sponsorships

This section describes an educational model at California Polytechnic State University that embeds industry-sponsored incentives and mentorship within a tertiary-level agricultural business course, aiming to spur entrepreneurial engagement and product innovation. Such an educational model positions students at the nexus of academia and industry, where they benefit from both theoretical knowledge and practical insights. The model comprises a triad of components: mentorship from industry practitioners, experiential learning through collaborative projects, and financial incentives for developing student-led innovations. The efficacy of this model was highlighted by the success of a student team reaching the final stage of a university-wide innovation competition, with their ongoing product development being a direct outcome of the course's structure.

The overarching goal of this teaching model is twofold: to enrich the existing literature on incentive-based learning within academia and to enhance pedagogical practices by demonstrating the value of industry collaboration. Specifically, the model aims to assess the impact of industry-sponsored incentives on student participation in innovation competitions, facilitate the transition of theoretical concepts into tangible prototypes, and generalize this teaching model for broader application within the academic institution. Central to this model is the course on "Innovation & Entrepreneurship in Agriculture," designed to serve as a bridge between students with entrepreneurial aspirations, existing university entrepreneurial programs, and industry collaborations. The course underscores the role of incentives in educational settings, drawing on previous research that establishes the efficacy of such approaches in achieving desired outcomes, notably through Deci, Koestner, and Ryan's (1999) examination of extrinsic rewards on intrinsic motivation, alongside further contributions from Vallerand et al. (1992), Amabile et al. (1994), Ryan and Deci (2000), and Pink (2009).

The process implemented within the course underscores an incentive-based learning structure. Financial incentives, furnished by industry partners, bolster the students' transition from theoretical learning to entrepreneurial praxis. In this context, a financial reward is extended for selecting the "best class project," incentivizing students to ideate and innovate with real-world applications and financial viability in mind. The incentive in question—a seed fund—covers the initial phases of product development, including formulation, marketing, and testing. This hands-on approach not only provides financial support but also incorporates the opportunity for students to present their ideas to industry leaders, thereby integrating mentorship and exposure to professional networks within the learning process.

The curricular structure is bifurcated into a dual-phase weekly format. The initial phase involves guided readings on entrepreneurial concepts, followed by interactive sessions that introduce key frameworks and discussions. The second phase is a collaborative workshop where students apply their newly acquired knowledge to their project, focusing on a specific agricultural sector. This project-based learning paradigm necessitates evidence-based decision-making, drawing on primary and secondary data to craft a comprehensive business model and value proposition. Outcomes from this educational model have been positive, with students reporting that the industry-sponsored incentives have not only enhanced their learning experience but also motivated them to further develop their classroom projects into viable entrepreneurial ventures. A particular student team exemplified this by advancing to the final

stages of a prestigious innovation competition with their new product concept. One team developed a hydrating ice cream aimed at providing seniors with a low-carb treat that also offers essential hydration. Another team created an innovative low-carb sports drink that delivers protein, catering to the needs of athletes seeking effective recovery and muscle support.

The significance of this model extends beyond the classroom; it also contributes to the broader academic community by connecting students to institutional innovation programs. This is further exemplified by ongoing research into the factors contributing to successful agricultural product innovation, a sector that presents unique challenges compared to other food industries due to its specific barriers to entry. The broader impact of this initiative has been disseminated through presentations to industry leaders to encourage the adoption of similar educational models in other institutions. These efforts create a collaborative environment that benefits local industry and has the potential to influence agricultural practices and innovation globally.

4.2 Questioning the One-Size-Fits-All Master's Thesis for Professional Option Students

Thesis projects represent a core component of AAE&A master's programs. When paired with effective mentoring, these projects can enhance student research capabilities, equipping them for the challenges of PhD programs or research-oriented careers. However, the issue with the prevailing one-size-fits-all approach is that significant portions of students in these programs desire careers in industry. In the industry landscape, the emphasis of problem solving often leans toward strategic thinking and breadth of knowledge rather than intricate modeling directed toward a single topic. The traditional master's thesis might not provide industry-oriented students with the optimal tools for success in their future careers. Moreover, professionally oriented students typically pursue shorter programs, rendering academic-based thesis research less likely to yield publishable outcomes for students and mentors.

A potential solution could be to redefine the concept of a thesis for master's students in agribusiness with a professional orientation. Over the past two years, instructors in the Applied Economics program at Utah State University explored transitioning toward a research model that prioritizes crafting and solving case studies as the core of the thesis, as opposed to the conventional thesis format. Not only can case studies be a valuable research tool (Boland 2020) but, creating a quality case study demands students to develop an in-depth understanding of specific markets, the operations of a particular firm, and the formulation of actionable strategies for a company grappling with real-world challenges. This reimagining of the professional option thesis entails two primary objectives: (1) equip students with a skill set that is more applicable to the industry and its associated challenges; and (2) enhance the potential for publishable output, benefiting students and their mentors. In practice, this shift requires reducing emphasis on reviewing the academic literature, while increasing research toward specific industries and companies. Additionally, there is a diminished focus on intricate modeling with an augmented emphasis on extracting strategic insights from well-executed empirical research. It also was helpful for students to leverage work from their class projects for their thesis. Specifically, this was relevant for the firm strategy course, where students are tasked with solving a problem for a local firm as part of the class. The students who do well on the project are encouraged to build upon it for their thesis. This allows them to put more research into their case-study thesis than they otherwise would. This approach has worked well with two recent graduates in the program, both of whom have successfully defended their theses and generated work suitable for publication in case study journals; two manuscripts have been accepted for publication. The conventional master's thesis may not fully cater to the needs of students pursuing careers in industry. This can be addressed by reimagining the thesis for professional-oriented agribusiness master's students and prioritizing case studies with real-world relevance and publishable output. Through this approach, the students can be equipped with the skills they need to excel in the industry while contributing valuable research.

5 Conclusions

Future success and sustenance of academic programs in higher education will lean heavily on the realization and acceptance of the need for an innovative environment that challenges the existing norms or views about the learning process and the instructor's role in supporting this process. This article intends to provide an overview of and discusses efforts and ideas to help foster such an innovative environment within AAE&A programs in higher education.

Among the various innovative ideas discussed in this article, creating unique course offerings with fewer credit hours or shorter terms can be leveraged to design micro-credentials. Micro-credentials are becoming increasingly popular and are gaining acceptance among organizations as a workforce skill enhancement option and as a means for improving potential employment avenues for students, while being enrolled in academic institutions.

Agribusiness courses provide an excellent opportunity for innovation design through industry partnerships and linkages. These courses can also help promote a culture of entrepreneurship by providing incentives and possibilities for capital funding when innovative ideas are generated, including graduate courses that focus on research. Innovation in the curriculum can also encourage students early on in their programs at both undergraduate and graduate levels to explore diversified career paths by acquiring information and building the necessary skill set that best fits their interests and experience.

Another unique opportunity to explore is creating short-term teaching exchange programs for faculty in AAE&A programs. These programs among collaborating institutions can provide a fresh perspective for improving or redesigning course content, enhancing faculty development opportunities, and promoting research avenues. The international teaching collaborations and exchanges could further forge partnerships and enhance innovations in GCED, leading to advanced student successes in an ever-changing work environment.

Last, it is essential to highlight that the primary intent of innovative curricula discussed in this commentary is to provide specialized focus on the learning of key concepts, which would benefit students in various ways—for instance, helping retain fundamentals through reviewing and practice sessions (e.g., Quiz Bowl Class), filling learning gaps in core concepts and skills (e.g., a "Topics in Agricultural Labor" class, a workshop class of Excel applications, single-credit lab courses, and courses on global agribusinesses and intercultural competency), learning through applications and creations (e.g., industry-sponsored student projects and ongoing research related to agricultural product innovation), and generating agribusiness scholarship by prioritizing relevant case studies over the traditional thesis option for master's students. Ultimately, the goal of these curriculum innovations is to assist students to transition from being consumers of knowledge to producers of knowledge. Future research projects (e.g., a survey for graduating seniors), beyond the scope of this commentary, could be explored to provide insight into whether such courses benefitted the students, particularly with a better understanding of core concepts, and to investigate and document the effectiveness of student learning through these teaching practices.

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Teaching and Educational Commentary

Engaging Students in Open Dialogue about Use of AI Tools in Economics Courses

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JEL Codes: A22, O33
Keywords: Dialogue, conversation, student engagement, policy

Abstract
The rapid expansion of artificial intelligence (AI) tools is a scary prospect for many of us in college teaching roles. But these tools are here to stay. After my own initial resistance to AI tools in the classroom, I decided to engage each of my classes in conversation about them. In this commentary, I describe my experience with engaging my undergraduate classes in open dialogue about the use of AI and developing a collective agreement about how AI tools can be used in the classroom. While some faculty may not be ready to use AI tools themselves for assignments and classroom activities, facilitating conversations with students about these tools is an easy and low-cost way to explore the use of AI tools in the classroom and develop reasonable, fair, and clear policies for classroom use. Working collaboratively with our students to determine the best use of AI, as these tools evolve, is vital to ensuring these tools enhance rather than detract from students' educational experience, as well as contribute to a culture of trust and respect that students value.

1 Introduction

"*Technology is anything that was invented after you were born*." –Alan Kay[1]

New technology is scary. Once upon a time, the pencil was scary. So was the calculator. Then it was the internet. Then it was the little internet-connected computer that we have attached to us at all times (e.g., a smartphone or smart watch). Artificial intelligence (AI), specifically generative AI, is the next frontier in technological advances. All of us are sitting around our conference room tables hemming and hawing—what will we do? Will *this* mark the end of higher education?

History suggests … probably not. But as with every new technology, education will change. And as we dive into these conversations about what that change will look like, it is important to remember that we have a very valuable resource at our disposal—students! And guess what … they are worried about AI, too! They are also confused and scared about AI, and they are unsure about what it will mean for their futures. They are also deciding when and how to engage with it. We are in this *together*. As James Lang writes in his book, *Cheating Lessons: Learning from Academic Dishonesty,* "We have to give the students opportunities to respond in authentic ways over which they have some control" (Lang 2013, p. 65).[2] To that end, in this commentary, I discuss the process I have used in setting AI policies in the economics classroom together *with* students.

[1] This quote is widely attributed to computer pioneer Alan Kay, although from what I can find it does not appear directly in any written record. I first encountered it in Kevin Kelly's book, *What Technology Wants* (2010, p. 235). I try to reflect on it whenever I am feeling grouchy about something new in the world.
[2] This book significantly influenced my approach to course design and teaching when I first read it, and I have retained many of the approaches in my teaching. I highly recommend it for anyone interested in thinking about how to design courses so that students are less likely to feel they want or need to cheat to succeed in class (regardless of the technology available).

But let me back up for a moment. My introduction to AI in the classroom was not pleasant. In early 2023, just a few months after ChatGPT was released, I received a homework submission from a student that was AI-generated. My first reaction upon seeing this assignment was … *This is not okay. This is cheating.* And I acted accordingly with our institutional process. I try to make it very clear to all students that if they are under stress or need support, they should come to me. The student who submitted this assignment did not and instead turned to what I considered cheating.

But as I got a little distance from the incident, I started to think … *Was I too harsh?* I knew I needed a policy to make it clear what was and was not allowed, so that I do not have to resort to the university policies for accountability and adjudication, which are also in flux when it comes to AI. But AI is still a bit overwhelming, at least for me (as of this writing, I am not ready to use it myself for tasks—maybe I will be soon). One thing I realized from the academic honesty process (and one thing I dislike about it generally) is that it puts us in opposition to students. Rather than working *with*, we are working *against.* As I reflected on this process, I realized I wanted to be working *with*. I asked myself, what does it look like to work *with* students when it comes to AI?

The first step, I figured, was a conversation. But to be honest, I was scared. One of the reasons I think many faculty are so comfortable with the lecture style of teaching (chalk and talk, sage on the stage, death by PowerPoint, etc.) is that it is *safe.* We have planned what we are going to say ahead of time. We have years' worth of notes. Conversations, on the other hand, can be scary. We do not know where they will lead. Students may ask us questions we are unable to answer, at least in the moment. Constructive dialogue with students requires vulnerability and humility. As bell hooks notes in her timeless book of essays on pedagogy, *Teaching to Transgress*, "any classroom that employs a holistic model of learning will also be a place where teachers grow, and are empowered by the process. That empowerment cannot happen if we refuse to be vulnerable while encouraging students to take risks" (hooks 1994, p. 21).

2 Having the AI Conversation

Before I get to the AI conversation with my students, I set the tone. It is important for students to know their perspectives and experiences are truly valued. I set this tone on the first day of class by asking students to write name cards with prompts for factoids in each corner. In one of the corners, I ask them to put something "they know a lot about." I find this exercise valuable for a few reasons. It reveals how confident (or not) students are, it reveals what they are passionate about, and most importantly, it provides a lead-in to a conversation about respect. I acknowledge that students know a lot about things that I probably do not know about. And I know a lot about some things (namely Economics) that they do not know much about. We each bring our specific experience and sets of expertise into the classroom, and it is sharing those experiences together that generate our unique learning environment and experience for that class in that term.

I have "the conversation" about AI on the first or second day of class *after* setting the tone for the course as noted above. It comes *after* discussing the outline of the course and reviewing the syllabus and course webpage in our learning management system so students know what kinds of work the course will require.

Here are the questions I pose to the whole class for open discussion and some accompanying explanation for the reader's benefit:

1. *Have you used ChatGPT or other AI chatbots?*
   It is important to understand the level of knowledge students have. If we have created a welcoming and respectful classroom environment, students will indicate they have used these tools, but in my experience (so far), their use is less common among students than the media hype would have us believe.

2. *Do you think they could be a useful tool in this course? If so, how?*
   It is important that this is presented *after* the presentation to students about what kinds of assessments and assignments will be used during the term. Then students can think about the use of AI *specifically* in the context of this course.
3. *In what aspects of class do you think the use of ChatGPT and other AI chatbots should be acceptable?*
4. *In what aspects of class do you think the use of ChatGPT and other AI chatbots should not be acceptable?*
   The last two questions are where we narrow down the specific agreements we want to have about when and how it is appropriate (or not) to use AI, and I write them on the board in an "acceptable" and "not acceptable" list. The goal with this part of the conversation is to try to come to some agreement about what is or is not okay so that everyone can buy into it. In addition, I encourage dissenting voices to speak up, asking "Is there anyone who has a different opinion? I expect and welcome other perspectives." I also share which elements I have concerns with and explain the nature of those concerns.
5. *Does everyone feel comfortable with the acceptable and unacceptable uses of AI I have written here?*
   In the end, my goal is for everyone (both me and the students) to buy into the AI policies for the course, and to feel the policies are reasonable, fair, and clear.

Within a few days of the conversation, I follow up with the class, adding language to the syllabus based on what we discussed and letting students know the language is there. Here is the language I added to the syllabus for one section of my Introduction to Microeconomics class in the 2022–2023 academic year. The language makes specific reference to the types of at-home assignments for the class (issue briefs and problem sets) and gives examples of the types of activities that are and are not allowed in the context of these assignments.

> ***Use of ChatGPT and Other AI Chatbots***
> *Per our class discussion on the first day, use of AI chatbots, including but not limited to ChatGPT, is allowed in this course as a study tool. For example, looking up terms and concepts that you are confused about is an acceptable use of AI chatbots in this course. Use of AI chatbots, including but not limited to ChatGPT, is not allowed in this course to solve or prepare homework answers. For example, asking an AI chatbot to summarize an article for which you are preparing an issue brief, write parts of an issue brief, or answer a question on a problem set are not acceptable. If you are ever in doubt about whether or not use of an AI chatbot is acceptable, please ask! Also, if you have suggestions for changes to this policy as we all figure out how AI chatbots can be used in our work, please let me know.*

Adding this language gives me a point of reference and my own policy so that I am not left trying to figure out whether use of AI is a violation of the broader academic honesty policy of the university. Additionally, since my colleagues and I may not all have the same policy, it attempts to make very clear what is allowable *in a particular class*. Other classes may be different, and it is important that we impart this to the students we engage with.

3 Reflections

Finally, I want to share a couple of observations from the conversations I have had with my classes (eight so far) and my experience dealing with suspected violations of the class-generated AI policies.

We as faculty may all have this impression that students are out there just throwing everything into ChatGPT, but I have been surprised by how few students have indicated they use AI tools. It is of course possible some do not admit to using them, but my sense is that many students have had similar

trepidations to me. This will certainly change over time, but it is important to recognize the media and tech world hype around AI may not reflect most students' experiences. I have also appreciated that this process yields different results depending on the class and on the quarter. In the four quarters I have had these conversations, they have changed, with students in the most recent quarters considering AI to be more acceptable than prior quarters, and more students indicating they have used AI than in the past. This has been important for me, helping me keep abreast of the rapid changes in this technology and its uses, and ensuring my policy remains reasonable, fair, and justified in light of these changes. Finally, the conversations have given me considerable peace of mind. They remind me that students are also anxious about these things and that many value learning and fairness in the classroom, things I also value.

That said, this approach is far from perfect, and I cannot at this time prove its efficacy; to do this I would need to run an experiment of some kind, and that is not on my agenda for the near future. Others are doing this type of experimental work in the classroom and beyond (e.g., Shear et al. 2023), and I read this work with great interest. My hypothesis is that the approach and framing I use around AI sets the tone for things to come, creating a respectful learning environment where students may be less likely to use AI in ways the class deems unacceptable. Student evaluations from my courses provide some support for this idea, highlighting the vibrant learning environment in the classroom as well as the focus on learning and critical thinking rather than grades within the classes I teach. However, because I have not received any specific feedback around the AI conversations in these evaluations, this feedback may have to do with broader aspects of class culture (of which the AI conversation is merely one aspect). Some students have also told me (unasked) when they have used AI to do certain things which are permitted under the policy. Unfortunately, I do still at times receive student work that appears to violate the AI course policies created with students. I believe it is my duty as the course instructor to enforce course policies, and so when I do suspect a student has violated the class AI policy, I address it. I do not currently have language on how the policy is enforced in the syllabus and have so far addressed it on a case-by-case basis, but I may add a question about appropriate enforcement to my conversation about AI policy with students next term.[3] I do find enforcement is easier for me and feels fairer when I have a class-level AI policy in place, as it gives me an easy reference in dealing with any suspected violations. I am sure I am not alone in finding it difficult to prove that AI has been used if students do not admit to it, so when I do suspect a violation, I ask the student who submitted the work outright if they have used AI, remind them of the course policy around AI, and give them the opportunity to redo the work on their own if they admit to using AI. In this interaction, I emphasize that in my experience, AI-related course violations are often driven by stress about grades or other things happening in life, and I want to support the student in dealing with that stress, but I need their help in upholding course policies. This is again in the spirit of working *with* and not *against* students, and as with all aspects of this approach, my enforcement methods are a work in progress.

AI is here. It is not going away. If we ignore it in our classes, some portion of our students will be taking advantage of it, with possible implications for equity and fairness. Addressing AI in the classroom does not require becoming AI experts overnight or becoming the AI police. To begin, it just requires a simple conversation.

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[3] I am grateful to an anonymous reviewer for encouraging me to reflect on this point.

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Research Article

Using Generative Artificial Intelligence to Aid Classroom Retention

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Abstract
The use of generative artificial intelligence (AI), which includes tools such as ChatGPT, Bing, and Bard, allows users to find information for specific questions with just a few keystrokes. While this technology is not a replacement for traditional research methods, it can help undergraduate agriculture students be efficient in their time management skills as they move through the various stages associated with writing papers. The question remains whether students increase their retention of knowledge from use of generative AI in conjunction with traditional course lectures. Participants in this research were provided with a video describing generative AI and then completed a course assignment using this technology. Using a pre- and post-evaluation, agriculture students self-assessed how use of generative AI aided retention of knowledge. Questions on the evaluation addressed whether students view generative AI as ethical to use for course assignments and in a professional business environment, if it will aid their future career plans, and if they are more likely to use generative AI due to the assignment. Use of generative AI in conjunction with a course assignment can aid in improved understanding of the benefits and drawbacks associated with this technology. Our analysis provides information on students' prior use of this technology and how it can benefit their retention of knowledge. Results indicate the extent to which students believe use of AI is ethical in business or professional settings, and previously earned dual enrollment credit indicates their retention of knowledge and change in beliefs toward its usefulness in future careers. Students were largely neutral on AI, aiding retention of knowledge more than a traditional lecture or their normal study methods.

1 Introduction

The integration of new technologies is an important component of the educational process for students as they pursue training to achieve their career aims. For students pursuing a career in business, economics, or STEM fields, the ability to successfully use technology is an important skill that is expected in normal job responsibilities. The ability to demonstrate competency in the use of technology during an interview process highlights a student's efficiency in completing tasks to aid firm productivity. This results in academic institutions making significant annual investments in new technology to aid student preparation for the job market. Adoption of technology by academic institutions allows students a chance to discuss the ethical framework associated with the technology.

Academic faculty's adoption of technology does not always match the educational institution's investment (Reid 2014). Reasons for low rates of technology adoption and demonstration by faculty are varied but can include their self-efficacy and background (Reid 2017). The relative newness of a technology and the lack of awareness by faculty members of its potential benefits can slow adoption rates and have negative impacts upon students' preparedness for the job environment. For example, the environmental portion of the Ishikawa fishbone diagram in Reid (2017) does not include industry's expectations of students' technological prowess, which might lead to greater adoption and diffusion of technology by academic faculty in the classroom. Increasing job preparedness among students increases

not only the value of the student's education, but society's view of the academy.

Generative artificial intelligence (AI) is a new technology that is in its early stages and generating much discussion regarding its appropriate use in curricula of academic institutions. ChatGPT, Bing, and Bard are examples of generative AI gaining attention and popularity in society. AlAfnan et al. (2023) discuss consequences of the use of generative AI in the classroom resulting in concerns on plagiarism, unlearning, and academic and professional development. These are valid concerns given generative AI's ability to avoid plagiarism detectors. With the COVID-19 pandemic resulting in significant learning loss (Kaffenberger 2021; Donnelly and Patrinos 2022), generative AI can help mitigate the lack of knowledge undergraduate students are expected to possess even when analytical and critical-thinking skills are not fully developed. Faculty at academic institutions are well-placed to help frame student perceptions about the appropriate and ethical uses of new technology and are often expected to include discussions of ethical consequences in their courses by various accrediting agencies (Kulshreshtha 2005; Snyder and Bairaktarova 2021; Bosman, Oladepo, and Ngambeki 2024).

Businesses are jumping on the AI bandwagon as demonstrated by the investment in generative AI tools by Microsoft and Google, just to name a few (The Economist 2023, "Meet the New Co-Pilot," p. 58). Employers are using terms such as "co-pilot" for AI software, but there are concerns about incorrect information generated and use of confidential or proprietary data. The entire September 16, 2023, edition of The Economist was devoted to how AI could revolutionize scientific discovery. Yann LeCun, who is touted to be a "godfather of modern artificial intelligence" was quoted, "By amplifying human intelligence, AI may cause a new Renaissance, perhaps a new phase of the Enlightenment" (The Economist 2023, "I, Robot Scientist," p. 67).

Sullivan, Kelly, and McLaughlan (2023) highlight the possibilities of generative AI, including ChatGPT to enhance participation and student success. According to Sullivan et al. (2023), student perceptions regarding the potential benefits to students is missing from the existing research literature. Cotton, Cotton, and Shipway (2024) discuss the potential benefits to students from improved remote learning and creation of personalized assessments while Perez et al. (2017) suggest chatbot applications can aid with preparation of student-oriented study guides and lecture notes. For the latter study aid, this can be used to reinforce content from previous courses students have not fully mastered and/or retained. It is in this knowledge gap we seek to answer some of the questions raised in the existing literature on student use and perception of AI as it relates to career preparedness, its ethical use both for career and academic pursuits, and its ability to aid in retention of course knowledge.

This study analyzes student perceptions and knowledge of AI applications. Following completion of a pre-assignment survey, undergraduate agricultural majors completed an assignment using generative AI to determine how the activity helped retention of course material. A post-assignment survey was completed by students to measure the change in perceptions. This paper follows with a brief literature review, discussion of methods, presentation of results, and then concluding thoughts.

2 Literature Review

Incorporation of technology into academic curricula has long been part of the teaching process to prepare students for their future career paths. Higgins and Moseley (2001) find that adoption of technology by instructors is tied to student learning outcomes. These outcomes can vary widely by academic discipline due to the presence of accreditation bodies, including the Association to Advance Collegiate Schools of Business (AACSB). As an example, AACSB International requires universities receiving its accreditation in business that "learners and faculty are competent with current and emerging technologies" (AACSB International 2020, p. 22). For students who are in pre-professional tracks, the outcomes are focused on putting the student in a position to receive acceptance to a professional or graduate program. Non-accredited disciplines may see their faculty rely on existing knowledge, prior experiences, and training (Reid 2017). Faculty must also balance students who have

limited prior experience with technology. This can result in student frustration from lack of technical support from software developers, faculty assistance, and/or poor grades received on assignments. These frustrations can often result in poor student evaluations of teaching resulting in reluctance of faculty to adopt additional technology.

Ali (2003) states the importance of education in meeting the needs of society, and faculty's views toward the integration and suitability of technology is important. Newly adopted technology should be a tool to aid learning, not a solution to student learning (Gardner 1998). Thus, faculty can open students' minds to new possibilities with technology. With generative AI, society has already begun the adoption process with faculty having to decide the best way to introduce the technology into courses. Anecdotal evidence suggests the parents of undergraduate students expect academic faculty, including use of generative AI in curricula to prepare students for their future careers. This perception among parents competes with faculty concerns on the time it takes to learn and successfully incorporate new technologies into a classroom setting (Butler and Sellbom 2002). In consideration of generative AI's ability to evade plagiarism checkers and questionable veracity (AlAfnan et al. 2023), faculty may perceive the costs greater than the benefits of its use in academic settings. Regardless of faculty perceptions, industries are already adopting various forms of AI (Kumar et al. 2021; Carvalho and Ivanov 2024; Prieto, Mengiste, and de Soto 2023), necessitating the need for faculty to consider how to introduce students to this technology in an ethical manner consistent with how it will be used in job settings.

Following introduction of a new technology to students, they must still make an adoption decision. Social influences are known to impact student adoption of technology in higher education situations (VanDerSchaaf, Daim, and Basoglu 2021). Even as academic faculty work with undergraduate students who are highly connected, their knowledge and awareness of how to use technology is often limited (Chokri 2012). Tied in with the adoption decision is whether students will accept the technology. Davis (1989) suggests the actual use of a new technology is tied to the perceived usefulness, perceived ease of use, attitude toward using the technology, and behavioral intention to use. External variables are tied to the actual use (Davis 1989), which could include the social influences of an undergraduate's peer group and/or time constraints. Demonstration of its potential applications in future career paths may also assist in the decision to use.

The COVID-19 pandemic has had major implications for learning in the academy. Students were less concerned about studies, with increased focus on their overall well-being, potential loss of existing employment, and implications for their long-term career prospects (Pruitt, Tewari, and Mehlhorn 2020; Gonzalez et al. 2021; Birmingham et al. 2023; Soria, Horgos, and Shenouda 2023). With students less focused on learning, this has contributed to learning loss (Kaffenberger 2021; Donnelly and Patrinos 2022) and strategies to reduce the disruption to current and future undergraduate students (Black 2020; Hanson and Wachenheim 2020; Turner, Hughes, and Presland 2020; Kaffenberger 2021; Harmey and Moss 2023). Into this environment for higher education, ChatGPT and similar generative AI were released into the marketplace. With ChatGPT allowing the possibility of "personalized learning" (Firat 2023), this can be a useful tool to minimize the educational harm associated with the COVID-19 pandemic.

3 Methods

Undergraduate students at a regional teaching institution in the southeastern U.S. were invited to participate in this research on perceptions and ethical use of generative AI. These students were in a comprehensive agricultural department (i.e., offering majors in a variety of agricultural disciplines). Participating students in

agricultural economics, agricultural engineering technology, animal science, and general studies[1] completed a pre-assignment questionnaire assessing their knowledge of AI.[2] Questions addressed the extent of students' familiarity with AI and various chatbots, their ability to provide information to users, and whether students had used AI to assist with improving papers for high school or college credit. Data were also collected on students' perceptions concerning the ethics of AI in various contexts and whether the use of AI would be beneficial to their future careers. The uniform pre-assignment questionnaires were completed in the classroom. Students who were not present for the pre-assignment questionnaire were asked to visit the faculty member's office to complete the questionnaire. While participation in the AI project was mandatory in each class, it was left to each faculty member's discretion whether to provide points directly for completion of the questionnaire.

Following completion of the pre-assignment questionnaire, students watched a short video in class discussing and demonstrating generative AI using a pre-determined prompt.[3] Designed specifically for this project, the university's Office of Information Technology created and recorded the video shown to all students in the eight participating sections. All students were required to watch the video in class to ensure the video was viewed in full. Following the video, faculty discussed a course-specific assignment students would complete using generative AI. Students used the AI chatbot of their choice to complete the assignment, which was recorded on the post-assignment evaluation. The assignment was designed to reinforce course content in each of the respective courses. One example assignment involved using a chatbot to produce simple definitions for several complex terms, creating a quiz to test student knowledge and application of those terms, and engaging in an optional back-and-forth interaction with a chatbot to incorporate those complex concepts into a verbal discourse.

After the submission of the assignment, faculty administered the post-assignment evaluation. Likert-style questions on the post-assignment evaluation focused on whether students perceived the use of AI improved understanding of chatbots/AI, whether the use of AI helped the student retain content more than a traditional lecture, and whether they are more likely to use AI in the future. The Likert scale ranged from "strongly disagree" to "strongly agree." Only one question—whether students believe being proficient in AI will benefit their career—was repeated across pre- and post-assignment surveys to track changes in perception. Student responses were tied to their university student identification number, allowing us to match their responses at both points in the semester.

The Likert questions on the post-assignment evaluation are hypothesized to be impacted by the questions on the pre-assignment evaluation (familiarity with advances in AI, whether AI use is ethical in school and/or business environments, and whether the student has previously used AI for school purposes) as well as demographic variables. Given the ordinal nature of the variables, an ordered probit model is used to assess which variables impact student's opinions on the usefulness of AI to help retain knowledge.

Concerns about the external validity of Scholarship of Teaching Learning (SoTL) across universities may be present due to self-selection biases present among students when choosing a university (Lupton 2019). Even with these differences, Lupton (2019) argues that students answered similarly across universities. Bernstein (2018) argues teaching innovations, as we are proposing, should be evaluated on how well it works, and broadly, findings can be applied. The context has been discussed in this section to help readers better understand and make the determination on its applicability to their courses regardless of the type of the university or discipline similar to the discussion in Shulman (2013) and Bernstein (2018).[4]

[1] The general studies course described in this research is a course freshmen take to aid in their transition to a university setting. Each section is organized by major and discusses how to register, what courses to take, and where to go when you face various issues commonly encountered by college students.

[2] All procedures for this study were pre-approved by the university's Institutional Review Board (IRB-24-970-E05-4005).

[3] Students who missed the video watched it in the faculty member's office. The video is available upon request.

[4] We wish to thank an anonymous reviewer for raising this point about internal and external validity in SoTL research.

4 Data Summary and Results

A total of 186 students completed both surveys, with six providing inconsistent class selections across their pre- and post-assignment questionnaires. Students in this research were primarily from the southeast, with 85.5 percent from the state in which the institution is located with an additional nine states represented in our sample. Means and standard deviations for the demographic information is provided in Table 1. Three variables were significantly different at the 5 percent level between upper and

Table 1: Demographic and Summary Data.

Variable	Mean	Standard Deviation
Female	0.489	0.501
Minority Student	0.086	0.281
Junior or Senior	0.425[a]	0.496
Out of State Student	0.145	0.353
Student Earned Dual-Enrollment Credit	0.677	0.469
Student Has a Minor	0.091[a]	0.289
Semester Grade Point Average	3.184	0.658
Days Between Completing Pre- and Post-Evaluation	37.392[b]	25.797
Student Used a Chatbot Other Than ChatGPT	0.167[a]	0.374
Bard	0.016	
Sonic	0.005	
Bing ChatGPT	0.016	
Perplexity	0.011	
YouChat	0.005	
Other	0.114	
Upper Division Course	0.371	0.484
Survey Completed for:		
Agribusiness General Studies	0.200	0.401
Agricultural Engineering Technology General Studies	0.141	0.348
Veterinary Sciences General Studies	0.119	0.325
Agribusiness Courses	0.195	0.397
Agricultural Engineering Technology Courses	0.141	0.348
Animal Science Courses	0.178	0.384

Note: There were 186 total responses for the pre- and post-evaluation assessment.
a Denotes a significant difference between upper and lower division courses at the 5 percent level.
b Denotes a significant difference between upper and lower division courses at the 1 percent level.

lower division courses: (1) whether the student was a junior or senior, (2) if they had declared a minor, and (3) if they used a chatbot other than ChatGPT. One variable (days between completion of the pre- and post-assignment questionnaire) was significant at the 1 percent level, but that may be impacted by the broad ranges present in the data.

Table 2 presents means and standard deviations for the questions included on the pre- and post-assignment evaluations. Only two statements were significantly different between upper and lower division courses at the 5 percent level of significance: (1) being proficient in AI will benefit my future career on the pre-assignment evaluation and (2) the use of this assignment improved my understanding of chatbots/AI. For the question involving how proficiency in using AI would benefit students' future

Table 2: Pre- and Post-Assignment Survey Results.

Statement	Pre-Assignment Survey		Post-Assignment Survey	
	Mean	Standard Deviation	Mean	Standard Deviation
I am familiar with the latest advancements in artificial intelligence (AI) that enable users to seek information from AI systems.	3.297	1.153		
I am familiar with chatbots and AI including ChatGPT.	3.238	1.210		
I have used AI (e.g., ChatGPT, Bard) to assist with improving papers I've submitted for credit in high school or college classes.	1.778	1.053		
Submitting college assignments completely written by AI is ethical.	1.751	0.886		
Submitting assignments completely written by AI in a professional business setting is ethical.	1.800	0.902		
Being proficient in using AI will benefit my future career.	2.935[a,b]	1.082	3.373[b]	1.041
The use of this assignment improved my understanding of chatbots/AI.			3.773[a]	0.861
Using AI helped me retain content more than a traditional lecture.			3.049	0.946
Using AI helped me retain the content more than my normal study methods.			3.043	0.977
Using AI in this class resulted in me being more likely to use this technology in the future.			3.297	1.070

[a]Significantly different between upper and lower division courses at the 5-percent level.
[b]Significantly different at the 1-percent level from same question administered on the initial survey.

careers, there was a significant difference at the 1 percent level between the pre-assignment and post-assignment evaluation.

Matching student responses by their institutional identification numbers, cross-tabulation results are provided in Tables 3 to 5. Nearly three-quarters—134 of 186—of students surveyed disagreed (strongly or otherwise) that submission of a college assignment completely written by AI was ethical and likewise disagreed (strongly or otherwise) with having used AI in the past to improve a high school or college paper. Three students strongly agreed with having used AI in the past, but strongly disagreed or disagreed with AI use being ethical to completely write an assignment. Similar results are presented in Table 4 for students who disagreed (strongly or otherwise) with the statement (1) that submitting assignments completely written by AI in professional settings is ethical, and (2) they have used AI in the past for high school/college assignments (70 percent or 130 of 186 students). Fourteen students agreed (strongly or otherwise) to having used AI in the past for assignment, disagreed (strongly or otherwise) with AI's use in professional settings as being ethical.

Table 3: Cross Tabulation of Prior Use of Artificial Intelligence and Submission of College Assignments Completely Written by Artificial Intelligence Is Ethical.

		Submitting College Assignments Completely Written by AI Is Ethical					
		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Totals
Used AI to Improve Papers in High School or College	Strongly Disagree	60	26	9	2	0	97
	Disagree	24	24	9	1	0	58
	Neither Agree nor Disagree	1	5	5	0	0	11
	Agree	3	5	4	1	2	15
	Strongly Agree	2	1	1	1	0	5
	Totals	91	61	28	5	2	186

Table 4: Cross Tabulation of Prior Use of Artificial Intelligence and Submission of Assignments Completely Written in Professional Settings by Artificial Intelligence Is Ethical.

		Submitting Assignments Completely Written by AI in Professional Settings Is Ethical					
		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Totals
Used AI to Improve Papers in High School or College	Strongly Disagree	58	25	11	3	0	97
	Disagree	19	28	8	3	0	58
	Neither Agree nor Disagree	1	6	2	2	0	11
	Agree	4	6	3	1	1	15
	Strongly Agree	1	3	0	0	1	5
	Totals	83	68	24	9	2	186

Table 5 presents cross-tabulation results of students' perceptions of whether AI proficiency will benefit their careers from the pre- and post-assignment evaluation. Slightly more than 20 percent of students (40 of 186) who neither agreed nor disagreed with the benefits of AI in their career felt the same across the semester. A total of 71 of 186 students (nearly 40 percent) neither agreed nor disagreed with the benefits of AI to their career at the end of the semester. Comparing the pre- and post-assignment evaluation, 44.1 percent had a more favorable view of how AI proficiency would benefit their career, 15.1 percent had a less favorable view, and 40.9 percent did not change their position.

Although not presented in the tables, the same percentage of females indicated perceiving the use of AI in school or business settings is not ethical (85.7 percent). This was a greater percentage than their male counterparts on either question. A higher percentage of students who were in lower-division courses indicated the use of AI in a business setting is not ethical (82.9 percent) compared with those in upper-division courses (78.9 percent). Prior use of AI in an educational setting was mildly correlated with lower term and college-level GPAs, with the same, albeit more muted, relationship with high school GPAs.

Table 5: Cross Tabulation of Being Proficient in Using Artificial Intelligence Will Benefit Career from Pre- and Post-Evaluation.

		Being Proficient in Using AI Will Benefit Career (Post-Evaluation)					
		Strongly Disagree	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**	**Totals**
Being Proficient in Using AI Will Benefit Career (Pre-Evaluation)	Strongly Disagree	8	5	9	4	1	27
	Disagree	0	3	11	6	3	23
	Neither Agree nor Disagree	2	6	40	28	5	81
	Agree	2	3	11	19	10	45
	Strongly Agree	0	0	0	4	6	10
	Totals	12	17	71	62	25	186

Given the ordinal nature for many of the questions posed on the post-assignment evaluation, an ordered probit model was estimated to determine the impact of demographic and pre-assignment questions on whether AI aided knowledge retention more than traditional classroom methods and whether usage in these would promote future usage (see Table 6). In Table 6, the degree to which students felt AI use in business settings is ethical and single-semester GPAs were shown to be statistically significant whether AI aided in retention more than conventional study methods and whether the assignment promoted future AI use. Dual enrollment was statistically significant in all three ordered probit models presented in Table 6. The signs for the previous independent variables were consistent each time the variable was significant, though magnitudes varied. Previous usage of AI for school assignments was statistically significant only in the model for examined factors impacting whether AI aided retention more than normal study methods. Having a minor was a statistically significant determinant of whether a student is likely to use AI again in the future.

Table 7 provides the marginal effects for significant and non-dummy variables based on the results of Table 6. As an exemplary interpretation of these marginal effects, a one-unit increase in the semester GPA (one letter-grade shift) yields a 3.3 percent increase in the student strongly disagreeing with AI aiding in knowledge retention over normal study methods. None of the marginal effects are greater than 9 percent for a one-unit change in the independent variable.

To measure shifting student opinions on whether they felt AI proficiency would benefit their career, a change variable was developed to capture differences in pre- and post-assignment responses. Student perceptions could have decreased, meaning the change variable would have been negative. To use an ordered probit model, this variable was rescaled (the most negative change, -3, was rescaled to 0, and the most positive change, 4, was rescaled to 7). By doing so, we were able to determine which factors impacted the change in students' perception of the utility of AI in benefiting their future career. The time elapsed between the pre-assignment evaluation, course assignment, and post-assignment evaluation varied between and within classes. It may be assumed more days between the pre- and post-assignment evaluations might allow students to consider the benefits of AI and more fully integrate AI into their learning processes. However, the impact of the number of days between the pre- and post-assignment evaluations was not large or statistically significant in any model and was excluded from the results presented.

Table 6: Ordered Probit Results of Artificial Intelligence Helped Retention of Course Content.

Variable	AI Helped Retention More than Normal Study Methods	AI Aided Retention of Content More than Traditional Lecture	Using AI in This Class Resulted in Me Being More Likely to Use This Technology in the Future
	Coefficient (Standard Error)		
Intercept	1.566***	1.472***	1.213**
	(0.584)	(0.581)	(0.582)
Upper Division Course	0.012	-0.029	0.033
	(0.102)	(0.102)	(0.103)
Familiarity with Latest AI Advancements	0.102	0.068	0.074
	(0.099)	(0.098)	(0.099)
Familiarity with Chatbots	-0.120	0.007	-0.057
	(0.087)	(0.086)	(0.087)
Previously Used AI for School	0.239*	0.193	-0.045
	(0.125)	(0.124)	(0.123)
AI School Assignment Usage Ethical	0.2399	-0.061	-0.017
	(0.125)	(0.118)	(0.118)
AI Business Assignment Usage Ethical	0.213***	0.073	0.274***
	(0.082)	(0.081)	(0.083)
Dual Enrollment	0.286*	0.319*	0.316*
	(0.173)	(0.172)	(0.172)
Minor	0.269	-0.192	0.769***
	(0.280)	(0.279)	(0.286)
Semester GPA	-0.306**	-0.110	-0.231*
	(0.127)	(0.126)	(0.126)
Female	-0.176	-0.268	-0.191
	(0.166)	(0.166)	(0.166)
Minority Student	-0.157	-0.008	-0.285
	(0.289)	(0.288)	(0.286)
Junior or Senior	-0.214	-0.141	0.077
	(0.167)	(0.166)	(0.166)
Threshold Parameter 1	0.956***	1.040***	0. 747***
	(0.097)	(0.100)	(0.096)
Threshold Parameter 2	2.045***	2.216***	1.643***
	(0.104)	(0.103)	(0.098)
Threshold Parameter 3	3.523***	3.436***	3.038***
	(0.179)	(0.161)	(0.141)
N	186	186	186
McFadden's Pseudo R-Squared	0.054	0.034	0.064
Log Likelihood Function	-240.180	-242.402	-247.437

Note: Standard errors in parentheses. Three asterisks (***) denote significance at the 1 percent level, two asterisks (**) at the 5 percent level, and one asterisk (*) at the 10 percent level.

Table 7: Marginal Effects of Independent Variables on AI Helping Retention More than Normal Study Methods.

	Marginal Effects for AI Helped Retention More than Normal Study Methods				
	Strongly Disagree	**Disagree**	**Neither Agree Nor Disagree**	**Agree**	**Strongly Agree**
Previously Used AI for School	-0.026	-0.051	-0.010	0.071	0.015
AI Business Assignment Usage Ethical	-0.023	-0.045	-0.009	0.064	0.014
Semester GPA	0.033	0.065	0.013	-0.091	-0.020
	Use of AI Increased Likelihood of Using in the Future				
	Strongly Disagree	**Disagree**	**Neither Agree Nor Disagree**	**Agree**	**Strongly Agree**
AI Business Assignment Usage Ethical	-0.030	0.025	-0.034	0.070	0.040
Semester GPA	0.025	0.038	0.029	-0.059	-0.033

Note: The marginal effects represent the percentage change of the dependent variable given a one unit change in the rating of the independent variable. Only significant and non-dummy variables from Table 6 are shown.

Familiarity with chatbots, beliefs about whether AI usage is ethical in business settings, semester GPA, and whether the student is a female were statistically significant in explaining changes in students' feelings about the career benefits of AI proficiency (see Table 8). It is interesting to note that the sign on the degree to which students believe use of AI is ethical in business settings is negative compared to positive in the models presented in Table 6. This variable (use of AI is ethical in business settings) had the largest impact on changing opinions on the usefulness of AI in their future careers. The marginal effects of these significant, non-dummy variables are presented in Table 9. As most of the changes ranged between a one-unit decrease and a two-unit increase (92 percent of observations), the marginal effects are centered around no change in feelings. A significant portion of students (76) did not change their opinion of AI's benefits to their career.

5 Conclusions

Generative artificial intelligence is disrupting university classrooms in its ability to help students find information and edit assignments. The ability of generative AI to aid in retention of knowledge was the subject of this research. Newness of this technology may have resulted in students neither agreeing nor disagreeing on its ability to aid in retention of knowledge delivered in courses, as over 80 percent of students disagreed with having used AI previously for a high school or college assignment. Students may not have understood the ability of AI to master agricultural concepts due to lack of awareness of the technology for these types of applications. Student concerns over regenerative AI not being current on information and making up information was not controlled in this study, and may have contributed to the results discussed in this paper.

The nature of the assignments used in the classes covered in this research may have contributed to students being uncertain on its ability to help retain knowledge, but it did result in improved understanding of this technology. Increased exposure to technology may further increase students' likelihood to use this new technology in the future, especially when students are asked to initiate the use as they were in the assignment for this research (EDUCAUSE Center for Analysis and Research 2018, p. 18–20).

Table 8: Ordered Probit Results of Change in Feelings Toward Artificial Intelligence Aiding.

Variable	Coefficient (Standard Error)
Intercept	6.284***
	(0.598)
Upper Division Course	0.069
	(0.103)
Familiarity with Latest AI Advancements	-0.072
	(0.099)
Familiarity with Chatbots	-0.154*
	(0.088)
Previously Used AI	0.069
	(0.125)
AI Assignment Usage Ethical	-0.116
	(0.119)
AI Business Assignment Usage Ethical	-0.723***
	(0.085)
Dual Enrollment	0.160
	(0.174)
Minor	0.435
	(0.282)
Semester GPA	-0.247*
	(0.128)
Female	-0.522***
	(0.168)
Minority Student	-0.376
	(0.291)
Junior or Senior	0.090
	(0.168)
Threshold Parameter 1	0.601***
	(0.168)
Threshold Parameter 2	1.532***
	(0.133)
Threshold Parameter 3	3.078***
	(0.113)
Threshold Parameter 4	4.261***
	(0.133)
Threshold Parameter 5	5.226***
	(0.201)
Threshold Parameter 6	6.336***
	(0.435)
N	186
McFadden's Pseudo R-Squared	0.048
Log Likelihood Function	-266.956

Table 9: Marginal Effects of Independent Variables on Change in Feelings Toward Artificial Intelligence Aiding Career.

	Marginal Effects							
	Largest Decrease in Feelings (Y = 0)	**(Y = 1)**	**(Y = 2)**	**No Change in Feelings (Y = 3)**	**(Y = 4)**	**(Y = 5)**	**(Y = 6)**	**Largest Increase in Feelings (Y = 7)**
AI Business Assignment	0.004	0.016	0.092	0.171	-0.169	-0.095	-0.019	-0.001
Usage Ethical Familiarity with Chatbots	0.001	0.003	0.020	0.036	-0.036	-0.020	-0.004	-0.000
Semester GPA	0.001	0.006	0.032	0.059	-0.058	-0.033	-0.006	-0.000

Note: The marginal effects represent the percentage change of the dependent variable given a one-unit change in the rating of the independent variable. Only significant and non-dummy variables from Table 8 are shown.

As business and industry embrace the use of AI in the workplace, educators need to provide exposure and guidance on its uses. It is unknown the extent to which universities are actively recruiting students based on their opinions of AI and is a potential area of future research. Clear guidelines on when it is acceptable to use generative AI and how to use it will increase student confidence in the future given the difficulty faculty experience in detecting its use with existing AI detection tools. This is an area for future research to determine what employers consider responsible use of this technology.

Our study is limited by the fact we did not compare perceptions of AI between agricultural and non-majors at our university. All of the classes in which the questionnaire was distributed were agricultural science courses. There might be significant differences between the types of classes (e.g., general education or major classes). This is in addition to potential differences between land-grant universities and regional, teaching institutions. Both of these are areas for future research as AI technology continues to evolve and student adoption of this technology increases.

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