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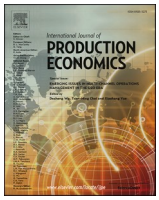

Adoption and transferability of joint interventions to fight modern slavery in food supply chains

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ABSTRACT

More than 50 million people in the world are estimated to be in a situation of modern slavery, the most extreme form of labour exploitation. Many of them are working in sectors such as mining and agriculture, which produce price-sensitive commodity products and where workers are particularly vulnerable. Against this challenge, we analyse a successful intervention against modern slavery in a place that has been labelled the "ground zero of modern slavery in the US". The Fair Food Programme was established in the tomato growing industry in Immokalee, Florida, and is based on an innovative joint action between farmers, buyers, and workers. We use an agent-based model built on qualitative field data to explain the success of the programme and to investigate whether the programme could be successfully transferred to other contextual settings. We model several market structures and measure the time it takes for all actors in the system to join the Fair Food Programme after a shock event (such as a case of modern slavery being discovered) triggered a dynamic of joint action. Our model shows that a high heterogeneity in farmer sizes leads to an increase in the time taken for them all to join the Fair Food Programme, while a high heterogeneity in buyer sizes speeds up reaching the tipping point towards joint action. We discuss these results and their implications for the transferability of the Fair Food Programme as a voluntary, incentive-driven approach towards tackling modern slavery, to other locations and contexts.

1. Introduction

Over 50 million people in the world live in a situation of modern slavery, the most extreme form of labour exploitation (ILO and Walk Free Foundation, 2022). This problem is most critical in labour intensive sectors such as agriculture and mining, which rely on the availability of cheap labour. Modern slavery is fuelled by global migration, as it is often the only employment opportunity for undocumented migrants in need of income. Employers and middlemen tend to take advantage of migrants by hiring them in exploitative working conditions. Exploited workers often find themselves employed in the informal economy, operating entirely outside of existing regulatory environments and unprotected by labour laws. As a result, modern slavery is not visible to enforcement agencies, and companies benefiting from these exploitive labour conditions often close an eye on the dire conditions in which these workers live. Innovative solutions are required to curb this issue. This paper analyses the conditions that led to the success of one of these solutions in the context of tomato farming in South Florida and studies its replicability to other contexts. In the United States, modern slavery is particularly problematic in the farming sector in the South, due to the presence of large populations of undocumented migrants who work in exploitive condition. They live in fear of deportation by the government, which limits their ability to speak up and complain about their poor labour conditions (Rothenberg, 2000). Labour-intense tomato farming in South Florida has been recognized as a particularly problematic sector in this regard. In the 1990s, several cases of modern slavery have been identified thanks to the efforts of a worker organisation and successfully prosecuted in the tomato fields in South Florida, resulting in over 1000 workers living in slavery being freed (Estabrook, 2011). The region around Immokalee, FL was considered the "ground zero for modern slavery" (Estabrook, 2011, p.22). Since then, and despite an increasing awareness about these instances of modern slavery, working conditions

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did not improve much, with workers continuing to be underpaid, receiving no medical insurance, no sick leave, no paid overtime or vacation.

In response to these ongoing exploitive practices, a worker movement emerged and created the Coalition of Immokalee Workers (CIW), a charity advocating for improved labour conditions for agricultural workers. After pleading with their employers for better conditions with little success, the CIW was able to persuade tomato buyers to commit to better working conditions for pickers. This led to the creation of their Fair Food Programme (FFP), an agreement where buyers (supermarkets, fast food chains) and farmers pay tomato pickers an extra "penny per pound" for the fruit they pick and commit to abide by higher working standards. Participation in the programme is entirely voluntary for all actors, and buyers and farmers can decide to join or leave anytime. The only requirement for a buyer or farmer in the programme is to buy/sell tomatoes in priority from sellers/to buyers that are part of the programme and pay the extra penny per pound. This market-based mechanism relying only on supply and demand to nudge companies towards the right behaviour has been enormously successful; so successful that other charities including organisations in Africa and China are currently trying to re-create what the FFP has achieved. However, to this day, no other organisation has been able to replicate this model with such success. Understanding the key success factors of the FFP in Immokalee is therefore needed to successfully implement the model in other contexts.

In this paper, we study the FFP through a simulation model to assess what are the conditions that made this programme successful. Most common scientific methods struggle to study one off events like the success of the CIW, a single organisation. Computer simulation offers a potential solution allowing to replicate the system and conduct controlled experiments of unique situations; see for example Axtell (2002). In particular, we examine the relationship between the CIW's success and the structure of the industry they are operating in (tomato picking in Florida), using field data and an agent-based model. Specifically, we want to find under what conditions a farmer or buyer decides to join the FFP. We test our model with different industry structures, to understand whether the size of buyers or farmers, or the heterogeneity in buyer or farmer size leads to a faster adoption of the FFP. We intend to answer the following research questions: (1) What are the conditions supporting the adoption of a fair food programme by buyers and farmers? and (2) How can such success be replicated in different contexts?

This paper contributes to theory in multiple ways. First, it describes a unique and counter intuitive programme which relies exclusively on market-based incentives to nudge supply chain agents towards offering their staff fair working conditions. Whereas typical anti-slavery intervention mechanisms rely on punitive approaches (audits, fines), public opinion (boycott campaigns) or consumer preference (fair trade labels) to induce the right behaviour (Caruana et al., 2021), the FFP we study in this paper relies only on supply and demand-based incentives. This programme is unique in the sense that it has been developed and deployed by the workers themselves and has gained a wide acceptance among buyers and farmers. It therefore follows a truly sustainable approach because it is not dependent on some CSR goodwill of companies or donations from external donors (Gold et al., 2018). Such worker led, sustainable programs to combat modern slavery have seen limited attention in the literature (Reinecke and Donaghey, 2021), and our paper contributes to developing this knowledge. Second, we identify the market structures (e.g., size and heterogeneity of buyers and farmers) which lead to stronger or weaker adoption of the FFP, and therefore contribute to building theory on modern slavery in supply chains (cf. Gold et al., 2015). Finally, this paper illustrates how issues of sustainability and in particular the well-being of workers, also labelled as "compassionate operations" (Sarkis, 2012) can be integrated into the core of production economics. By modelling the behaviour of supply chain agents within an agriculture production system, we show that simulation is an appropriate method for testing different market structures and identify optimal conditions for a successful acceptance of an anti-slavery program.

Our study contributes to practice by giving similar worker-led movements useful indications about the important characteristics for such programme to be successful. It analyses an intervention mechanism that has been successful in one context and provides insights into the optimal market structure for setting up such system. Based on our findings, other organisations can replicate the success of the FFP in other countries and sectors.

The next section provides a theoretical background about modern slavery, and existing measures to combat it. Section 3 describes the methodology we follow. Section 4 presents the results of our research, and Section 5 concludes the study by discussing its main findings.

2. Theory and background

2.1. Literature and theory

Modern slavery is a complex societal problem. Its persistence hampers advancement of various Sustainable Development Goals of the United Nations, while being particularly at odds with Goal 8.7 to end all forms of labour exploitation by 2030 (Gutierrez-Huerter et al., 2023). As an umbrella term modern slavery comprises serious forms of labour exploitation and phenomena such as debt bondage, forced labour and trafficking in persons (O'Connell Davidson, 2015). Propelled by media coverage of related atrocities, modern slavery has developed into a "zero-tolerance issue" and has received vigilant attention by the general public, civil-society organisations, business and policymakers. This has led to new policy and legislation such as the Council of Europe's 2005 Convention on Action Against Trafficking in Human Beings, the California Transparency in Supply Chain Act (2010), the UK Modern Slavery Act (2015) or the Australian Modern Slavery Act (2018), urging business and civil society to ban modern slavery (Caruana et al., 2021). Legislation such as the California Transparency in Supply Chain Act obliges in particular larger companies to take action and to report about their measures to combat modern slavery (Birkey et al., 2018).

As modern slavery and other forms of severe labour exploitation are usually hidden in fragmented (regional or international) supply chains (Gold et al., 2015), backed by enabling macro-economic conditions such as specific industry, socioeconomic, geographic, cultural, or regulatory contexts, and recreated and exploited by firm-level capabilities such as accounting opacity and labour supply chain management (Crane, 2013), eradicating modern slavery is not straightforward. Some research has addressed the question of why modern slavery is not effectively tackled on a company and an industry level. Although individual managers react negatively to suppliers failing to meet sustainability minimum standards (Zhan et al., 2021), Meehan and Pinnington (2021) show how strategic ambiguity helps companies to reduce accountability and avoid change when confronted with anti-slavery regulation. Based on endogeneity of law theory, Monciardini et al. (2021) point to the phenomenon of managerialization of modern-slavery law, when symbolic and ineffective structures are associated with legal compliance, and thus legal requirements are tamed in the interest of business organisations. On an industry level, Gutierrez-Huerter et al., 2023 longitudinal study on how various actor groups frame modern slavery in the UK construction sector, provides evidence on the dynamic interplay of morally competing frames. This specific interplay has inhibited substantial industry-level change, although this high-risk sector has set up a multi-company initiative for addressing slavery in its operations and supply chains (Trautrims et al., 2021).

The agricultural sector has a high risk of labour exploitation due to its high labour intensity and relatively low skill requirements (Gold et al., 2021). In agriculture, more than two million people work under conditions of modern slavery worldwide (ILO and Walk Free Foundation, 2022). For example, Sozinho et al. (2018) have exposed the historical association of the Brazilian sugarcane industry with human rights

abuses. Although affluent countries are generally less concerned with severe forms of labour exploitation, regions with high number of refugees or trafficked people, as for example in Greece, Southern Spain, the United Kingdom and the South of the United State (Izcara Palacios and Yamamoto, 2017; Chesney et al., 2019; Kougkoulos et al., 2021; Phillips and Trautrims, 2021) may face major problems. For example, Chesney et al. (2019) explore for the area of Campo de Dalías in Almería (Spain) how the conditions of labour demand and supply through immigration inflows influence management practices of labour exploitation. Drawing on social life cycle assessment (S-LCA), Blackstone et al. (2021) have evaluated how specific US retail supply chains of fruits and vegetables are affected by forced labour risks, thereby identifying supply chains where priority intervention is required by business, authorities, and civil society. It was found that major forced labour risks in food supply are associated with US domestic supply chains; this shows that labour exploitation is no remote problem located in far-off regions, but also affects the very countries that generate its demand (Gold et al., 2021).

The intricate, interconnected and often hidden nature of labour exploitation makes it a grand societal challenge that cannot be tackled by actors in an isolated manner but requires coordinated and concerted efforts by various actor groups (George et al., 2016). As possible responses, literature has repeatedly highlighted multi-stakeholder initiatives such as the International Cocoa Initiative (ICI) (Gold et al., 2015) and community-centred approaches that focus on changing institutions and underlying socioeconomic conditions that make people vulnerable to exploitation (Muthuri et al., 2012). Despite some consensus that joint approaches are important for tackling modern slavery, it remains unclear under which conditions exactly such collaboration turns out to be effective. In fact, there are several examples where well-intended multi-stakeholder action does not yield substantial improvements on a systemic scale (Matos et al., 2020), as recently shown for the case of the UK construction sector (Gutierrez-Huerter et al., 2023).

Principally, multi-stakeholder initiatives face the problem of collective action as conceptualized by Olson (1971); this means that rational, self-interested actors tend to be reluctant to support the interest of a large group embracing a range of different actors, without proper incentives or compulsion. There is currently only little knowledge about how to set the proper incentives for addressing the grand challenge of labour exploitation. A system dynamics modelling based longitudinal case study of Tata Chemicals Magadi (Kenya) shows how a positively reinforcing loop of inclusive collaboration can be fostered through the creation of "we feeling" among all relevant actors (Gold et al., 2018). For creating such joint action, formerly marginalized groups have to be given, and actively assume, agency and responsibility. Similarly, Reinecke and Donaghey (2021) advocate putting workers themselves into the centre of the decent work governance architecture through a logic of democratic participation, which is labelled "worker-driven supply chain governance". In this way workers and communities become agents of change towards decent working conditions as opposed to dependent beneficiaries (cf. Muthuri et al., 2012; Gold et al., 2018).

While the worker-driven approach was realized through the CIW and the FFP, and has been described in a recent ethnographic study as "ensemble leadership" (Rosile et al., 2021), the success of the CIW remains little understood. This means that it is unclear whether and under which conditions the initiative could be transferred to other contextual settings, for example to a hot spot of labour exploitation in the Global South. An objectifiable attribute of the CIW and FFP is its network and market structure that likely affects the success of collective action, i.e., the speed and degree to which the various network actors decide joining into collective action. Previously there has been a stream of research on the diffusion of sustainability through supply networks depending on network configurations and size asymmetries (see for example Gold et al., 2020). The view of supply chains and production systems as complex networks is well established in research (e.g., Basole and Bellamy, 2014). Considering centrality, density, complexity, and distance network measures, Gold et al. (2020) have previously pointed to the special role of "sustainability nexus suppliers" in diffusing labour standards, and the effects of specific industry types. For their analysis, they applied a coercive power-based diffusion mechanism pushed by the buyer, which has been variously criticized and is at odds with worker-initiated change (e.g., Rosile et al., 2021). Other scholars have highlighted that collaboration (e.g., Vachon and Klassen, 2006), commitment (Locke et al., 2009) or trust (e.g., Peters et al., 2011) are equally or even more effective for bringing about sustainability in supply networks.

For the case of a worker-driven movement such as the FFP, dynamics appear to be driven by collaborative institutional work, which is comprised of co-building common ground, promoting interactional openness among parties involved, and engaging in diffusion (Michel, 2020). Lawrence et al. (2009) define institutional work as all efforts aimed at affecting (creating, maintaining, or disrupting) an institution or a set of institutions, i.e., norms, beliefs and rules of action (Michel, 2020). Institutional change has been investigated as result of collaborative efforts among various actors, thus highlighting the worth of coalitions and alliances (Wijen and Ansari, 2007). It is less understood though how network structure and agency of actors interrelate when aiming for institutional change, e.g., when aiming for altering working conditions for low-skilled jobs in an agricultural setting. Battilana and Casciaro (2012) have found that low levels of structural closure (i.e., a less cohesive networks featuring structural holes) help the agent initiating more radical institutional change, while it hinders incremental institutional change. For advancing our knowledge at the network-agency interface, we investigate how the interaction between network structure and institutional work by the CIW has facilitated joint collective action of all relevant actors.

2.2. Empirical background

The CIW was formed in 1993 with the goal of improving the working lives of tomato pickers in Florida. They created a Fair Food Programme (FFP) which would see buyers such as Walmart, Burger King and McDonalds who join, pay an extra "penny a pound"; an extra cent for each pound weight purchased. This money would be spent on increasing tomato picker wages. In addition, the CIW set up a training scheme to be given to all pickers prior to starting work at member farms, and a complaints system to allow workers to report abuses. There was initially little interest in the industry. Then on November 20, 2007, three workers employed by a gang master (i.e., an employer of enslaved workers) who had a contract with a number of farmers, managed to escape from the makeshift prison they were being forcibly held in, and the CIW was able to publicise their story (Estabrook, 2011). Two massive family run farms immediately took note and, going against the wishes of their industry body, joined the FFP. Realizing that they could be held accountable for these events in their supply chain (Gong et al., 2019; Wilhelm et al., 2016), several buyers followed and joined the FFP. Since then, more buyers and farmers have joined and the CIW's programme has taken off. The CIW history is described in more details in Estabrook (2011) and in Rawal (2014)'s documentary.

2.3. Gap and contribution

Modern slavery has been broadly tackled on a governmental level by legislation in several countries; however, in response to such regulation, companies have often tried to managerialize modern slavery laws, by focusing primarily on legal compliance structures such as related disclosure, which are often ineffective to tackle the phenomenon in its core (Monciardini et al., 2021). Market-based interventions using demand and supply balance to nudge supply chain actors toward the morally good behaviour are rare, and research on such mechanisms is limited. We address this gap by focusing on the FFP, a mechanism created by workers which has proven to be effective at combating modern slavery.

Although previous literature recognizes the importance of joint approaches for tackling modern slavery (e.g., Gold et al., 2015; Trautrims et al., 2020; Benstead et al., 2021), there is limited evidence about the specific conditions which make such multi-stakeholder approaches successful. We aim to fill this gap by studying the conditions that led to FFP's success in combating modern slavery, and the incentive system that led to the adoption of the program. In particular, we focus on the adoption speed of the FFP by two important supply chain actors, farmers and buyers.

Although some studies have analysed worker-led governance efforts in supply chains and pointed towards the need of empowering workers (e.g., Benstead et al., 2021; Reinecke and Donaghey, 2021), the body of knowledge about such initiatives is still limited. We contribute to this gap by studying the success of the CIW. Specifically, we analyse the factors and conditions which will allow the FFP to be transferred to other labour exploitation contexts.

Institutional work theory has been used to study similar settings in the agricultural sector (e.g., Michel, 2020). However, it is not well understood how the network structure and agency of actors interrelate for supporting institutional change. We address this gap by investigating how the interaction between network structure (i.e., size of supply chain actors) and institutional work by the CIW has enabled collective action of all relevant actors.

Finally, on a methodological level, apart from the work by Chesney and colleagues (Chesney et al., 2017, 2019; Chesney, 2021; Gold et al., 2020), agent-based modelling has not yet been substantially exploited in the context of modern slavery and labour exploitation. Agent-based modelling is especially powerful when analysing single case studies where a systemic phenomenon (i.e., the occurrence or prevention of modern slavery) emerges from complex interactions of multiple actors (i.e., the behaviour of supply chain actors). Our agent-based modelling approach shows its usefulness for analysing the qualitative social issue of worker well-being within the frame of production economics, and demonstrates the potential of agent-based modelling as analytic and prescriptive tool for "compassionate operations" (Sarkis, 2012) management more generally.

3. Methodology

3.1. Choice of methods

The adoption of the FFP in the tomato picking sector in Immokalee is a one-off event. This makes it extremely difficult to analyse with typical quantitative methods, or even qualitative research methods such as multiple case study research, because the researcher cannot use cross-case comparisons to draw conclusions. One-off events clearly do not allow for controlled experiments, because the event cannot be replicated in a controlled environment. In addition, using controlled experiments for studying modern slavery issues in a real-world setting would be questionable from an ethical perspective (for example, manipulating the job market to assess whether a farmer agrees or not to improve the labour conditions of their workers would not be acceptable). Given the limited quantitative data available from a single case, inferential statistics such as null hypothesis significance testing using primary data is not feasible (Cumming, 2013, p.423).

With these limitations, simulation is one of the few scientific methods that allows for the study of a one-off event (Hammarberg et al., 2016). Simulation allows a researcher to build a model (referred to as the object of study) that is a fair representation of a phenomenon observed in reality (referred to as the target of study) (Winsberg, 2010). That model can then be experimented on or explored by repeatedly changing parameters, running simulations, and observing resulting outcomes. There are two extreme approaches: 1) the model is based on theory only and researchers are testing that theory; or 2) the model is constructed through empirical observations of the target and then different scenarios are explored to develop theory. Many simulations sit somewhere in the middle of these two extremes, and our model of the FFP is closer to the second.

A model built on empirical observations is only meaningful and reliable if it is based on high quality data collected from a real case. In this paper, we develop an empirically informed simulation model, using qualitative data collected at the CIW through a series of observations and interviews held over 2 day at their headquarters in Immokalee and the surrounding farmland. This rich data gave us an in-depth understanding of the case and allowed us to identify important characteristics that may explain the success of the FFP initiative. Based on this knowledge, we develop several hypotheses that could potentially explain this success.

We test our hypotheses using an agent-based simulation model. Agent-based modelling is a popular simulation technique (Gilbert, 2007), although it is not yet common in business studies. It involves creating 'micro' rules governing the behaviour of individual agents, and scenarios within which those agents interact with each other. Scientists can then observe the 'macro' behaviour—effects seen at the level of society—that emerges from the micro rules. These micro rules can either be taken from a theory to be tested or from empirical observations to be explored (Chesney, 2021).

Our work is of exploratory nature because it starts from an inductive approach based on empirical data (i.e., not on existing theory). Agent-based models can be used for exploratory research (Chesney, 2021), for example to identify effects that have not previously been observed or thought of before, and in so doing, develop hypotheses which can then be tested (Stebbins, 2001). By replicating large number of runs (e.g., 1200 in our case), agent-based modelling allows to use inferential statistics to test these hypotheses, an approach which is not available in other exploratory research approaches.

Agent-based modelling does also give a powerful approach not easily available to other methods—sensitivity analysis (Wilensky and Rand, 2015). Sensitivity analysis involves identifying how a certain model outcome variable changes as the model parameters take on particular initial values (Saltelli, 2002). It answers the question of how sensitive that variable is to the initial values of the other parameters. This allows for assessing different scenarios and strategic options—varying parameters to observe the results that appear and their frequency. Such an exploration may suggest hypotheses of interest.

3.2. Case study

In the first step of our research, we collected qualitative data to get a solid understanding of the CIW and its FFP initiative. For this, we studied available literature, news stories, videos, and reports to understand the background and most important steps in the CIW's history. Based on this preliminary research, we built a semi-structured interview protocol to guide our discussion with the CIW staff (see Appendix A in Supplementary data) and ensure that all important questions are covered during the interview (Myers and Newman, 2007). Next, we visited the CIW headquarters in Immokalee, Florida and met with several staff involved in the FFP. We spent two full days with the CIW, interviewing staff, observing their worker training and payroll auditing activities, and being shown the FFP's work and the realities of tomato harvesting workers in a live setting. Interviews are an efficient way to collect rich empirical data about an infrequent event such as the creation of the FFP (Eisenhardt and Graebner, 2007). We conducted individual interviews with six staff/volunteers over the course of 2-h long interviews. We then conducted a 2-h long group interview (Myers and Newman, 2007) with five staff. This group interview allowed us to gather perspectives from a broader set of respondents and benefit from the interaction between participants as a "stimulus to elaboration and expression" (Frey and Fontana, 1991, p.184). We also used this group interview for validating the previously conducted individual interviews (Frey and Fontana, 1991). The research team took an active role in leading this interview. One researcher led the discussion using a

Table 1
Rules dictating the behaviour of agents in the FFP and our model.

Rule	Action
Rule 1a	Buyers will join the FFP with a low probability. This is intended to model institutional pressure on buyers to join, coming from the CIW. Buyers have two levels of membership. At Level 1, they agree to buy preferentially from farmers that are members of the FFP; at Level 2 they agree to buy exclusively from farmers that are members.
Rule 1b	With a low probability, a small number of farmers may join the FFP because of a shock in the industry. This will happen at most once each run and is intended to model the shock that initially caused several farmers to join the FFP as detailed in Section 2.2.
Rule 2	Buyers at Level 1 will assess their market and will move to Level 2 if the number of tomatoes being produced in each time period by farmers that are members of the FFP is greater than or equal to the number of tomatoes required by buyers in the FFP.
Rule 3	At FFP Level 0, buyers will buy what they need from any farmer. Buyers at FFP Level 1 will preferentially buy from farmers at FFP Level 1. Buyers at FFP Level 2 will only buy from farmers at FFP Level 1.
Rule 4	Farmers at Level 0 assess the market and will move to Level 1 if the number of tomatoes the farmer produces is greater than the number required by buyers with FFP Level 0.

semi-structured interview protocol (same as for individual interviews, see Appendix A in Supplementary data), and the second researcher took notes. The discussion was also recorded and later transcribed. Finally, the research team had many informal conversations with workers, CIW staff, and local residents during the fieldwork.

Given the sensitivity of the content discussed, we commit to keep names and functions of our respondents anonymous. However, we can attest that the interviewees all have roles with responsibility within the CIW and the FFP. While the first interview was scheduled in advance with the CIW manager hosting our research team, the names of the respondents for the other interviews (individual and group interviews) were identified following a snowballing procedure (Eisenhardt, 1988). The individual and group interviews were conducted face-to-face by both researchers. We also had several follow up calls and email exchanges with our interviewees after the initial research visit to clarify our understanding and validate our assumptions with the leadership of the CIW.

The interviews were transcribed, and the entire research team analysed them to understand the functioning of the FFP and identify possible reasons explaining the success of this program. First, we identified the rules dictating the behaviour of buyers and farmers in the FFP mechanism (see summary in Table 1). Second, we identified the important characteristics that could explain the adoption speed of the FFP by buyers and farmers. We detected the agents' size and heterogeneity (i.e., market structure) as one of the important characteristics for our model. We extensively discussed this assumption and the rules governing the FFP (Table 1) with the CIW staff to validate our approach, and they confirmed that our understanding of the FFP was correct. Finally, we used the insights from this case study to develop a set of hypotheses (see Section 4) which informed our model building and subsequent testing of results.

3.3. Agent-based model

The model was created in NetLogo, a specialized language which takes care of many of the essential elements needed for agent-based modelling such as randomisation (Wilensky and Rand, 2015). The two supply chain agents that join the FFP are buyers and farmers. *Buyers* are the companies buying tomatoes (e.g., Walmart, Taco Bell, McDonalds), and *Farmers* are the companies producing tomatoes, which are the ones employing the tomato pickers and therefore play a central role in ensuring fair labour conditions. At the start of each simulation run, a number of buyer and farmer agents were instantiated. The industry structure (i.e., the agents' size) was varied by keeping the total number of tomatoes produced constant, but varying the number of buyers, the number of farmers, and their size. Buyer size refers to the number of tomatoes required in each time period, and the farmer size the number of tomatoes available in each time period. These sizes were varied randomly, and the Gini coefficient (Gini, 1955) used afterwards to measure the heterogeneity of each simulated industry, one for buyers (*Buyer Gini*) and one for farmers (*Farmer Gini*). Industry structure is further discussed in Section 5. Then in each discrete time period, agents applied the rules described in Table 1.

In Immokalee, the FFP had existed for years before it got widely adopted by the industry. The spark that caused adoption can best be described as an industry shock. This happened when the police and CIW rescued a group of tomato pickers who were held captive in the back of a truck. Two major farms were so bothered by this discovery that they joined the FFP, against the will of their industry body. To test for the impact of such a shock in our model, at a random time after the simulation begins (*Shock time*), there is an industry shock, which represents a modern slavery scandal (Caruana et al., 2021) becoming widely publicized and generating a response by stakeholders. The size of the shock (*Shock size*) is measured in number of farms being affected. These farms are randomly selected to immediately join the FFP. The size of the farms involved is not considered in this selection.

Given Rules 1a and 1b, all buyers and farmers will eventually join the FFP, which gives each run a natural stopping condition. However, it will take the system more or less time until it reaches this point (Time to join), depending on the market structure. *Time to join* is the outcome variable of our model, measured as the time between the shock and when all farmers joined the FFP. It therefore indicates the adoption speed of the FFP. At the end of each run, we extracted the data for all independent and dependent variables (see Table 2).

After building this model, we presented it to the CIW staff, who validated all model assumptions and behaviour. By "closing the loop" (Pedraza-Martinez and Van Wassenhove, 2016) with the respondents, we ensure that our model is a correct representation of reality.

4. Hypotheses development

In this section, we develop the hypotheses that will be tested with our agent-based model. Following an exploratory approach, we develop these hypotheses inductively from the insights collected from our case study (i.e., not departing from existing theory). Since the CIW staff we interviewed did not have preconceived ideas about the direction of each effect (i.e., positive or negative), we did not include signs in our hypotheses.

In our first set of hypotheses, we expect the average size of agents

Table 2
Independent and dependent variables.

Independent Variables (model parameters)	
Buyer size	Average size of buyer agents
Farmer size	Average size of farmer agents
Buyer Gini	Heterogeneity of buyer size (Gini coefficient)
Farmer Gini	Heterogeneity of farmer size (Gini coefficient)
Shock size	Number of farmers involved in the shock
Shock time	Time at which the shock occurred
Dependent Variable (outcome variable)	
Time to join	Time for all farmers and buyers to join FFP (time between shock and all farmers and buyers joined)

(farmers and buyers) to affect the adoption speed of the FFP. We develop the hypothesizes H1a and H1b as follows.

H1a. The size of buyers will impact the adoption speed of the FFP

H1b. The size of farmers will impact the adoption speed of the FFP

Next, we assume that the heterogeneity of agents' sizes will impact the adoption speed of the FFP. The adoption speed has been found crucial when resource-limited actors aim at making entire markets more sustainable (Beltagui et al., 2020). In other words, we assume that having a few large agents and several small agents will lead to different adoption speeds, compared to the initial assumption of all agents having similar sizes. This assumption is realistic, since larger agents joining the FFP will create a substantial shift in the volume of FFP tomatoes produced, and thus nudging smaller agents to join as well. However, one could also argue that large agents have a strong market power, and their unwillingness to join the FFP will delay the decision by other agents. Based on these two potential effects, we do not include a sign in our hypotheses H2a and H2b.

H2a. The heterogeneity of buyer size will impact the adoption speed of the FFP

H2b. The heterogeneity of farmer size will impact the adoption speed of the FFP

Finally, we assume that the size of the shock (i.e., the initial slavery event triggering the first farmer to join the FFP) will affect the adoption speed of the FFP. Indeed, a stronger shock will build up higher institutional pressure and incentivize more farmers to join the FFP. We therefore develop hypothesis H3.

H3. The size of the shock will impact the adoption speed of the FFP

5. Results

To generate our dataset, we varied the following parameters: buyer and farmer size, heterogeneity of buyer and farmer size, the size of the shock, and the time at which the shock occurs. We ran 1200 simulation runs with different variations of these variables. In each scenario, we ran the agent-based model until all farmers and buyers joined the FFP. The time between the shock and when all farmers and buyers joined (Time to join) is the dependent variable in our model.

5.1. Preferential attachment model

In this first step, we used a "preferential attachment model" to generate heterogeneity in buyer and farmer sizes (Barabási and Albert, 1999). This model results in a few large agents, and many small agents (see Fig. 1, left panel). For a variety of reasons, we would expect to see this industry structure in reality (Newman, 2010).

After having processed all simulation runs and generated our dataset, we tested our hypotheses H1-H3 with a simple linear regression model, as shown in Equation (1). The variable Shock time is not connected to our hypotheses, and we use it just as a control variable (and to calculate the dependent variable Time to join).

$$Time\ to\ join = \alpha_0 + \alpha_1 Buyer\ size + \alpha_2 Farmer\ size + \alpha_3 Buyer\ Gini + \alpha_4\ Farmer\ Gini + \alpha_5 Shock\ size + \alpha_{67} Shock\ time + \varepsilon \quad (1)$$

The results of this regression are shown in Table 3.

From these results, we see that the coefficients for Buyer size and Farmer size are significant, and take a negative sign, which indicates that as the size of buyers and farmers increases, the time it takes for all agents to join the FFP decreases, which allows us to validate hypotheses H1a and H1b.

The coefficients for Buyer Gini and Farmer Gini are both significant. The coefficient for the variable Buyer Gini has a negative sign, which indicates that as the heterogeneity of Buyer size increases, the time to join decreases. This means that if there are few large buyers and many small buyers, it will take less time for all buyers to join.

The coefficient for the variable Farmer Gini is significant and has a positive sign. This means that as the heterogeneity of farmer size increases, the time to join increases. If there are few large buyers and many small buyers (i.e., a fragmented industry), it will take more time for all farmers to join. Based on these findings, we can confirm hypotheses H2a and H2b.

Finally, the coefficient for Shock size is not significant, which means that there is no significant impact of the shock size on the time to join. We can therefore not validate hypothesis H3. The control variable Shock time is also not significant.

Randomly varying multiple parameters at the same time, as we did for creating Table 3, was useful to identify general relationships between variables. However, it does not allow to identify the direct effect of a particular change in market structure. For this reason, we created

Table 3
Regression results with heterogeneous agent size.

	Estimate	Std. Error	t value	Pr (>|t|)
(Intercept)	5562.76	216.72	25.67	0.0000
Buyer size	−1.344	0.268	−5.02	0.0000
Farmer size	−1.352	0.268	−5.05	0.0000
Buyer Gini	−567.063	126.36	−4.49	0.0000
Farmer Gini	1273.82	127.79	9.97	0.0000
Shock size	−2.189	8.456	−0.26	0.7957
Shock time	0.0564	0.0551	1.02	0.3065

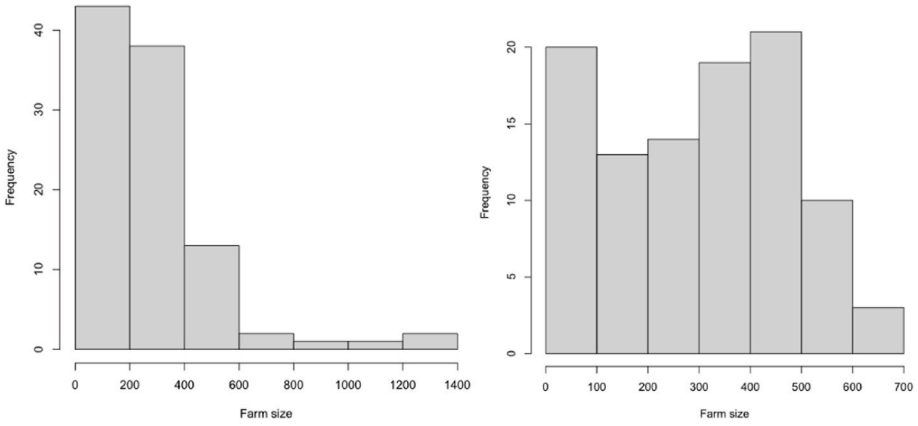

Fig. 1. The panels show the frequencies of farmer sizes in one simulation run, for unequal sized farmers under a preferential attachment model (left), compared with a random model (right).

Table 4
Correlations among the model variables where agent sizes follow a preferential attachment model.

	Buyer size	Farmer size	Buyer Gini	Farmer Gini	Shock size	Shock time	Time to join
Buyer size	1.00						
Farmer size	0.00	1.00					
Buyer Gini	−0.01	0.00	1.00				
Farmer Gini	0.00	−0.01	−0.01	1.00			
Shock size	0.00	0.00	0.00	0.00	1.00		
Shock time	0.01	−0.01	0.05	−0.12	0.33	1.00	
Time to join	−0.13	−0.14	−0.12	0.27	0.00	−0.01	1.00

additional datasets, for which we only varied one model parameter at a time. We present the result of this process in Table 4, which shows the pairwise correlation coefficients among the model variables.

The main point to highlight from Table 4 is the positive correlation between Farmer Gini and the dependent variable, Time to join ($r = 0.27$). This implies that the more unequal the structure of the farming industry, the longer it will take for farmers to join. This confirms our findings from the regression results (Table 3) and our hypothesis H2b. There is also a small negative correlation between Buyer Gini and Time to join ($r = -0.12$), which confirms the regression results and hypothesis H2a.

Time to join is also negatively correlated with the buyer size ($r = -0.13$) and farmer size ($r = -0.14$). This confirms our regression results and supports hypotheses H1a and H1b. As found in Table 3, the shock size does not seem to be related to the time to join ($r = 0.00$). This is perhaps surprising, but in fact it suggests that the shock alone is not enough to induce change among all farmers and buyers. However, it seems that the type of firm impacted by the shock is more important. Indeed, if a large farm gets a shock (i.e., a case of modern slavery discovered), it will join the FFP, and this will induce a ripple effect throughout the industry (Chen, 2022), prompting other farms as well as buyers to join as well to make sure they can access to enough tomato supply and safeguard their reputation. However, if a small farm is impacted by a shock, it will also join the FFP, but the effect on the entire industry will be much more limited and slower.

5.2. Random size model

To further assess the impact of the heterogeneity of buyer and farmer sizes on the dependent variable Time to join, we created a second dataset in which the buyer and farmer sizes were randomly assigned (see an example in Fig. 1, right panel). As a result, all buyers and all farmers have similar sizes, leading to a Gini coefficient close to 0. We run the same tests (regression and correlation) with this new dataset and show the results in Table 5 and Table 6. The coefficients for Buyer size and Farmer size are still significant (at $\alpha = 0.05$ level), with a negative sign. As in the preferential attachment model, we can validate hypotheses H1a and H1b. In Table 5 we see that the coefficients of Buyer Gini and Farmer Gini are no longer significant, suggesting that the results are heavily dependent on the heterogeneity of agents' size in the industry.

Table 5
Regression results with similar agent size.

	Estimate	Std. Error	t value	Pr (>|t|)
Intercept	5261.9	252.15	20.87	0.0000
Buyer size	−0.985	0.3124	−3.15	0.0017
Farmer size	−0.754	0.3119	−2.42	0.0158
Buyer Gini	−29.95	1081.92	−0.03	0.9779
Farmer Gini	1221.2	1090.38	1.12	0.2630
Shock size	−16.213	9.9793	−1.62	0.1046
Shock time	0.0707	0.0569	1.24	0.2148

Similarly, the negative correlation between Time to join and Buyer Gini becomes positive ($r = 0.15$, Table 6). As for the preferential attachment model, under the random agent size model the shock size and the shock time have little impact on Time to join ($r = 0.04$ for Shock size, $r = 0.09$ for Shock time). The regression coefficients of these two variables are also non-significant (see Table 5).

5.3. Visualization

In this last section, we show a visual representation of a simulation run. Fig. 2 shows how the number of agents at each level of the FFP varies throughout one simulation run. In this example, we can see a clear tipping point around time $t = 3200$, after which all farmers rapidly join the FFP.

6. Discussion and conclusion

To solve the grand challenge of modern slavery in supply chains, millions of workers in supply chains need to be liberated, empowered, and the new enslavement of workers be prevented at a much larger scale than today. Our study advances the field of socially sustainable supply chains, and modern slavery in supply chains in particular (Gold et al., 2015), by utilising a quantitative modelling research method to investigate the scaling up of solutions and the transferability of successful market-based approaches. Best practices in fighting modern slavery and labour exploitation in supply chains have been scrutinized primarily by qualitative case study research so far which do not allow robust insights into their replicability. Furthermore, it contributes to the relatively new, but rapidly increasing social sustainability research in production economics that considers people in production systems and the impact of these systems on people (Sarkis, 2012).

For tackling modern slavery, effective approaches and the context in which they established themselves and operate need to be better understood so they can be transferred to other settings. In our study we investigated the FFP, a successful worker-driven approach (Reinecke and Donaghey, 2021) which operates in the agricultural sector in Florida, where labour exploitation was normalised, and cases of modern slavery well documented (Rosile et al., 2021). The question of how to replicate effective multi-stakeholder action toward modern slavery conceived as "societal grand challenge" (George et al., 2016) gains its importance by the fact that exploitation in labour-intensive agricultural operations is widely observed in many countries including affluent countries such as the United States and the United Kingdom (Izcara Palacios and Yamamoto, 2017; Phillips and Trautrims, 2021).

Sustainable change in supply chain and production systems conceived as complex networks (Basole and Bellamy, 2014) is determined by network structure and the agency of actors as well as the interrelation between structure and agency (e.g., Gold et al., 2020). Institutional change towards more sustainable value generation relies upon a change in norms, beliefs and rules of action which are diffused throughout the system (Michel, 2020). A "shock event" such as the

Table 6
Correlations among the model variables where agent sizes follow a random rule.

	Buyer size	Farmer size	Buyer Gini	Farmer Gini	Shock size	Shock time	Time to join
Buyer size	1.00						
Farmer size	0.00	1.00					
Buyer Gini	−0.01	−0.01	1.00				
Farmer Gini	0.00	−0.01	0.97	1.00			
Shock size	0.00	0.00	0.00	0.01	1.00		
Shock time	0.03	−0.03	0.01	0.01	0.37	1.00	
Time to join	−0.1	−0.08	0.15	0.15	−0.04	0.02	1.00

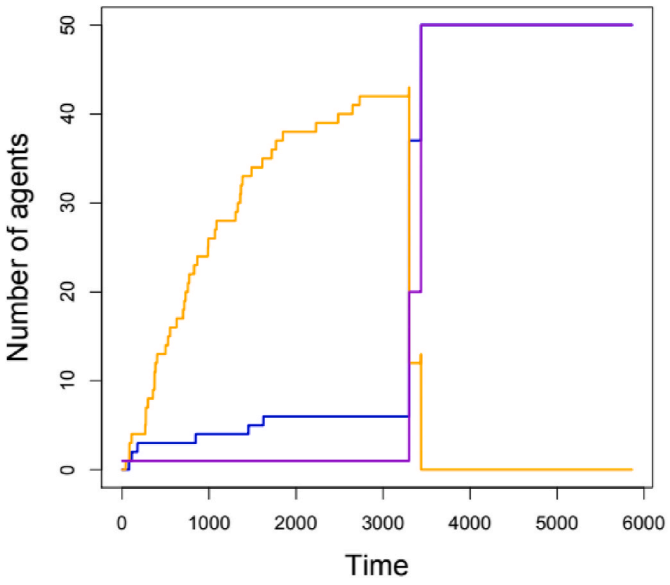

Fig. 2. Evolution of the number of agents in the FFP over time. Farmers are shown in purple. Yellow shows the number of buyers at FFP Level 1, and blue the number of buyers at FFP Level 2. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

detection of modern slavery at one tomato farm triggers institutional change at one or a few actors that further disseminates through the network if advocacy and awareness raising campaigns by the CIW have prepared the ground. The assumption of institutional change based on normative pressures is reasonable in the setting of the FFP, and in the agriculture sector in general, as agricultural businesses operate across sometimes vast areas of land, making it difficult to monitor working conditions without some willingness by the farmers to support the activities for improvement (Benstead et al., 2021). The degree of change that these actors can bring to supply chain and production systems depends on the network structure, i.e., the size and distribution of network actors such as farmers and buyers. Indeed, the variation of uptake speed of the successful FFP approach across our model scenarios shows that the market and supply chain structure indeed have a strong impact on the adoption of the program.

The FFP can be labelled a worker-driven supply chain social responsibility approach (Reinecke and Donaghey, 2021) and operates within a markets-based paradigm (i.e., driven mostly by supply and demand). Our study was interested in the structural context of the market and its supply chain actors to understand if the same approach can work in other agricultural supply chain and production systems. We found that when the market is composed of a few large buyers and farmers, the time it takes for all agents to join the FFP decreases. This is consistent with findings from Gold et al. (2015) who suggest that larger companies may find it easier to develop capacities for anti-slavery activities because they have more resources. Large companies tend to face more scrutiny about their practices to combat modern slavery in their supply chains, and recent anti-slavery legislation focuses mainly on these companies (Birkey et al., 2018). As a result, large companies are faster at adopting anti-slavery practices in their supply chains. However, other researchers found that large companies are not necessarily better at tackling modern slavery because for the sake of cost minimization, they may leverage buying power and "drive suppliers to the point at which terrible labour practices become an operating necessity" (New, 2015, p.703). This finding is not supported with our results.

We also find that the heterogeneity of the size of farmers has an important effect on the adoption speed of the FFP. In our model scenario with few large and many small farmers, uptake of the FFP takes longer. This is not astonishing as more farmers must be convinced to join; and social norms of exploitative practices may persist in a network of like-minded peers as discussed by Chesney et al. (2019). This finding is also in line with Gold et al. (2015) who suggest that small- and medium-sized companies operating in fragmented industries have more difficulties adopting anti-slavery practices in their supply chains. If we consider the change required by farmers for jointly tackling modern slavery as incremental, Battilana and Casciaro (2012) suggest that low levels of network cohesion, i.e. fragmentation, hinder spreading such incremental change.

The maintenance of the FFP as an institution and its advocacy and campaigning activities take up resources by the organisation setting up the institution (in our case the CIW). If these resources are depleted and the advocacy efforts exhausted before reaching the tipping point needed for the normalization of a new social norm (cf. Lawrence et al., 2009), the social movement may be curbed and even driven back in its market coverage and eventually be erased by those with vested interests in the previous status quo. Gutierrez-Huerter et al. (2023) give an account for the UK construction sector of how dominant actors may forestall the emergence of new patterns of action to eradicate modern slavery and preserve the status-quo. The time it takes to convince enough actors and reach the tipping point of institutional normalization can therefore be crucial considerations for successfully establishing a market-driven socially sustainable supply chain improvement like the FFP. In line with this, Beltagui et al. (2020) have pointed to the crucial role of speed when small sustainable start-ups with limited resources aim at transforming an entire industry, based on a System Dynamics model of Fairphone and the mobile phone market. Our results show that interventions in markets with many small farmers and/or buyers are slower to be adopted, and one may therefore need to look for multipliers in the network, for example influential peers or industry bodies, that can accelerate the dissemination of a new social norm across the system or otherwise risk running out of steam before system-wide change has been achieved. Such multipliers have been identified and conceptualized previously for example in the form of "sustainability nexus suppliers" (Gold et al., 2020), adapting the concept of nexus suppliers by Yan et al. (2015) to a

sustainability context.

Our study shows that companies can be motivated to participate in socially sustainable supply chain improvements and that uptake is dependent on industry conditions. The commercial incentivisation for companies to participate in sustainability initiatives, which has been highlighted on a generalized level by Olson (1971), played a prominent role in the FFP and our model. However, despite FFP buyers committing to preferentially sourcing from FFP farmers, the program's uptake depended on one farmer breaking ranks with the other farmers' refusal to engage with the FFP. This initial shock, usually a scandal that caused a normative crisis regarding the legitimacy of working conditions and the fear of negative reputational impact on the business or its owner, was the trigger for starting this dynamic. Businesses (buyers and farmers) may consider the cost for participating in the FFP as an insurance (Fracarolli Nunes et al., 2020) against the potential costs resulting from a scandal, for example through a loss of credibility. When the risk of public discovery is high, firms would rather invest in such responsible sourcing initiatives upfront to avoid the cost of a reputational damage (Chen, 2022).

In our model, the size and timing of the shock had only little impact on the uptake of the FFP overall as the shock was conceived to, first and foremost, immediately affect the supply chain actor involved. In a supply chain and production systems with deeply engrained norms regarding acceptable working conditions as often found in the agricultural sector (Chesney et al., 2019), this assumption appears reasonable. This result again underlines the role of multipliers as catalysts for disseminating new institutional norms across the system. This supports the key role of industry disrupters for change towards sustainability and suggests that we need to research such disruptors under consideration of its target industry's structures and contexts. This means looking deeply into the interrelation between supply network structure and agency of supply chain actors and other stakeholders that could drive social sustainability initiatives such as civil society organisations (Rodríguez et al., 2016). Going beyond the current study, the interface between supply chain structure and agency of single actors offers ample opportunities for follow-up research to advance social sustainability in supply chain management and production economics in theory and practice.

The real-world case of the FFP has benefitted from an oligopolistic supplier side with few, evenly sized farmers who could relatively easily supply each other's customers. In contrast, in a market with few large farmers and many small farmers, effective action is less likely if a small number of farmers starts joining the FFP for institutional pressure or proactive reasons. This is in line with findings from previous research noting the importance of buyer and supplier size heterogeneity in the adoption of sustainability practices in the supply chain (e.g., Gold et al., 2020; Zhan et al., 2021; Chen, 2022).

To conclude, we can answer our research question as follows. We find that a well-designed programme using market-based incentives has a strong potential to jointly combat modern slavery and bring positive change to an industry. We show that the market structure in the industry has a strong impact on the adoption of anti-slavery programs. The quickest adoption occurs when there are few large farmers and buyers, and when the buyer size is heterogeneous. However, when the farmer size is heterogeneous (i.e., few large and many small farmers), the adoption of the programme is slower. We also find that speed is of essence in the success of such anti-slavery programs. It is important for the organisation protecting worker rights (e.g., CIW) to reach the tipping point where most actors join before it runs out of resources. To speed up this process, it may use multipliers, i.e., influential actors that will incentivize others to join the program. In doing so, it should focus its efforts on large buyers, because these actors will lead other actors to adopt the program. Applying these insights will help an organisation replicate the success of the FFP in a different context.

Our study comes with several limitations. We have not considered whether a higher fluctuation of industry actors by businesses frequently exiting and entering the market impacts the uptake of the FFP and the transformation of social norms towards sustainability. This may be of interest for future research. Our model also relies on the shock being able to happen, which relies on the free operation of the FFP, media, and the presence of rule of law institutions. This is however not a given in many countries and may also indicate that an FFP approach would not be successful in situations of state-sponsored or state-tolerated modern slavery, unless the main market are foreign buyers. Finally, as with every simulation, our agent-based model is a simplification of reality, and despite having developed it based on multiple discussions with CIW staff, there remains a risk of missing important factors. Nevertheless, the different tests we conducted lead to similar results, which supports the robustness of our findings.

Declaration of competing interest COI

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ijpe.2023.108809.

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