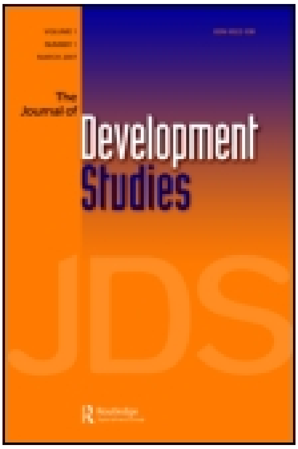

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Estimating the Impact of Small-Scale Farmer Collective Action on Food Safety: The Case of Vegetables in Vietnam

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ABSTRACT *This paper is an original empirical attempt to explain the outcome of collective action in the domain of food safety. We examine conditions and institutions that influence pesticide residue levels in vegetables using econometric analysis on data gathered from 60 farmer organisations in Vietnam. Findings suggest that collective action affects safety in that it provides members with technical assistance and monitoring for pest management at the farming level. They confirm the U-shape hypothesis of the effect of group size on safety performance which derives from the trade-off that exists between economies of scale and free-riding. The contribution of public authorities and ecological conditions to food safety remains controversial, while market forces do not yet seem able to drive the production of safer vegetables.*

I. Introduction

The Green Revolution has contributed to increased crop productivity and enhanced food security in many developing countries by promoting the adoption of high-yielding varieties combined with the intensive use of potentially hazardous agricultural chemicals (Hazell & Ramasamy, 1991). Furthermore, the dramatic urbanisation and rising incomes in urban areas worldwide has led to a steady growth of vegetable production in order to meet the expanding urban demand for more diverse food (FAO, 1999). Vegetables attract a wide range of pests and are subject to many diseases, requiring high applications of pesticides. Farmers in developing countries often apply pesticides excessively, misuse them or use acutely toxic insecticides that are in fact illegal (Tixier & De Bon, 2006). There is evidence of high pesticide use in peri-urban areas in some countries, with health exposure of urban consumers as a consequence (Dinham, 2003).[1]

Today's consumers in both developed and developing countries have become increasingly concerned about food safety. In developed countries, public and private safety regulations have gotten progressively intertwined and manage to ensure food safety (Henson & Caswell, 1999; Martinez, Fearne, Caswell, & Henson, 2007). This is not the case in most developing countries, where government institutions are significantly weaker and voluntary quality assurance schemes are still emerging. While there are some examples of exporting firms in developing countries that successfully adapt to

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international standards in order to access more lucrative markets (Henson, Masakure, & Boselie, 2005; Roy & Thorat, 2008), considerable worry remains around food safety in the less demanding domestic markets in such countries (Chemnitz, Grethe, & Kleinwechter, 2007). Furthermore, it is frequently asserted that small producers have more difficulty coping with the increasing prevalence of safety standards on international as well as national markets (Narrod et al., 2009; Reardon, Codron, Busch, Bingen, & Craig, 1999; World Bank, 2005). As a result, small producers may be excluded from high-value markets and their economic situation may deteriorate.

A solution advocated for small farmers to overcome these constraints is collective action (Reardon, Barrett, Berdegué, & Swinnen, 2009). Collective action in the domain of agriculture and food is recognised as providing several benefits: better access to inputs, better access to markets, reduction of transaction costs, increase of bargaining power and acquisition of a collective reputation, serving as a guarantee in the marketing of the product (Bosc et al., 2002; Markelova, Meinzen-Dick, Hellin, & Dohrn, 2009).

Collective action in the domain of food safety is still an emerging topic in academic literature. A main focus so far has been to show how collective action may facilitate the access of small farmers to demanding markets in terms of safety. Major actions that have been identified for fresh produce are: increasing farmer capacity to undertake joint investments (for example, infrastructure, labelling and certification); providing farmers with information, technical assistance and proper inputs; making possible vertical integration or contract farming; and building favourable conditions for the establishment of public-private partnerships (Berdegué, Balsevich, Flores, & Reardon, 2005; Henson et al., 2005; Moustier, Tam, Anh, Binh, & Loc, 2010; Narrod et al., 2009; Roy & Thorat, 2008).

Yet, the existing papers on collective action for food safety are mostly of a qualitative nature and do not provide econometric tests on the benefits of collective action to ensure food safety. Furthermore, they do not focus on the major challenge of collective action, that is free riding. Free riding can be defined as opportunistic behaviour that leads self-interested individuals to enjoy the benefits of a collective effort while contributing little or nothing to the effort (Olson, 1965). In the fresh produce industry, the collective good at stake is the collective reputation, which largely conditions market opportunities (Winfrey & McCluskey, 2005). Several scholars have identified a number of conditions and institutions that might limit free riding and facilitate the creation and maintenance of the collective good. The purpose of our research is to provide primary empirical evidence and econometric tests on the effectiveness of some of these conditions and institutional arrangements in limiting the misuse of pesticides in farmer organisations (FOs). Farmer organisations are formal forms of collective action (Hellin, Lundy, & Meijer, 2009), defined by Marshall (1998) as 'voluntary action taken by a group to achieve common interests'. In the next section, we introduce the literature on enabling conditions for effective collective action and safety provision. In Section 3, we present FOs and the issue of pesticide residues in Vietnam. In Section 4, we specify the conceptual framework, the research questions and the various hypotheses to be tested. In Section 5, we illustrate the data collection method, the measurement of variables and the econometric model. Finally, in Section 6, we present and discuss our findings, and in Section 7, we draw the main conclusions and make some policy recommendations.

II. Theoretical Insights

Field studies and evidence from all around the world have shown that the 'tragedy of the commons' is not unavoidable and people can efficiently cooperate and build institutions to govern collective goods (Ostrom, 1990). Most of the literature on collective action is related to the management of common-pool resources, such as fisheries, forests, rangeland and water resources. Agrawal (2001) synthesised the works of several previous authors (including Baland & Platteau, 1996; Ostrom, 1990; Wade, 1988) in an effort to identify factors that can lead to successful collective action outcomes, but little agreement exists on the direction, size and significance of their effects.

Some of these enabling factors are related to the characteristics of the group that influence the outcome of collective action. One of the most controversial issues relates to the size of the group.

Olson (1965) argues that smaller groups are more likely to engage in successful collective action because, as the size of the group increases, members realise that their individual contribution to the collective good becomes more and more marginal and, therefore, are more prone to free ride on the other members of the group. For instance, Winfree and McCluskey (2005) show that in large groups, the incentive to provide a quality contribution decreases. However, other scholars have remarked that the relationship between group size and collective action is not very straightforward and a trade-off between increase in free riding and potential economies of scale exists. For example, Marwell and Oliver (1993) find that the size of a group is positively related to the outcome of collective action, since collective action tends to happen when a critical mass of interested and resourceful individuals can coordinate their efforts. Some authors argue that the relationship between collective action and group size may have an inverted U-shape (McCarthy & Essam, 2009).

According to most literature on the commons, the level of social capital within the group is another characteristic that can positively affect the outcome of collective action. Social capital refers to the complex combination of traditional social ties, trust and norms of reciprocity that can lead to increased levels of cooperation among the group members (Baland & Platteau, 1996; Wade, 1988). However, it is difficult to find relevant indicators to measure social capital. Some authors use the level of kinship within the group as a social capital proxy (Di Falco & Bulte, 2010).

Education is also considered important for successful collective action. It has a twofold valence, limiting the free riding (Lyne, Gadzikwa, & Hendriks, 2008) – or in other terms, rising the cooperative behaviour (Lubell, Zahran, & Vedlitz, 2007) – and increasing the capacity of the individual to absorb more knowledge on Integrated Pest Management (IPM) and regulations and put it into practice (Caswell, Fuglie, Ingram, Jans, & Kascak, 2001; Fernandez Cornejo, 1998). But education may also increase the awareness that pesticides can yield less risks and higher incomes (Qaim & de Janvry, 2005), and also the ability to evade the monitoring system, so that the effect of education is ambiguous.

A further group characteristic that, according to the literature, can affect the likelihood of successful collective action is the extent to which group members depend upon the collective good (Demsetz, 1967; Dietz, Ostrom, & Stern, 2003). If the good is salient enough to the members, they would be more likely to be interested in protecting it and investing time and energy to create new institutions.

Organisational factors also influence collective action. A large amount of literature on new institutional economics has argued for the importance of institutional arrangements that the group may establish in order to improve the outcome of collective action. For instance, Baland and Platteau (1996) and Ostrom (1990) agree that the ability of members to collectively establish and modify clear rules and obligations adapted to local conditions can significantly reduce free riding and enhance the quality of the collective action. The provision of a forum of discussion also develops this ability by giving individuals the opportunity to discuss their problems with one another, find common solutions and supply themselves with shared rules (Varughese, 1999).

Once rules have been established, they should be monitored and enforced to ensure compliance and limit free riding. Ostrom (1990) argues that, without a reliable internal monitoring system, there can be no credible commitment to follow the rules. Group members can play a major role in directly monitoring each other's activity or they can choose to delegate this task to entrusted and qualified members or to inspectors they hire. Moreover, in order to limit opportunistic behaviour, a system of graduated sanctions should be applied to members that are found to violate the rules (Ostrom, 1990; Wade, 1988).

According to Agrawal (2001), most scholars on collective action have given only limited attention to factors external to the group, such as public authorities, markets and ecological conditions, and have ignored the fact that local groups and institutions – the focus of their analysis – are often created in conjunction with the external and nonlocal environment.[2] This has prevented the emergence of a better understanding of how external factors interact with local institutional arrangements and influence the output of collective action. Literature focusing on external factors such as public authorities or market forces that may influence firm behaviour with regard to food safety may fill this gap of understanding.

First, public authorities can support producers in increasing food safety levels by providing the required technical advice and resources. Several empirical studies have shown that farmers receiving specific training and technical assistance on IPM practices have been able to significantly reduce their dependence on pesticides (Caswell et al., 2001; Rejesus, Palis, Lapitan, Chi, & Hossain, 2009).

Furthermore, public authorities, besides setting statutory food safety standards, are directly involved in monitoring compliance therewith and imposing sanctions in the case of violations. A number of studies show that sound public enforcement of safety regulations represents an incentive for producers to undertake measures designed to ensure food safety (Henson & Caswell, 1999; Segerson, 1999; Starbird, 2000). Nowadays, most countries operate pesticide monitoring schemes, but the magnitude, reliability and scope of such schemes vary considerably from country to country (Shaw, 1999).

A discussion has arisen in recent years dealing with the potential for private self-regulation of food safety in contrast to public 'command and control'. A small amount of literature, but significant in content, has tried to determine the conditions under which market forces create adequate incentives for firms to invest in food quality and safety. Segerson (1999) shows that a strong mandatory threat (for example, that of a more costly system being imposed) is a necessary and sufficient condition for firms to adopt safety measures voluntarily for credence attributes. According to Venturini (2003) the firm must be able to promote or value the voluntary nature of its initiative with the consumer, and the government intervention in the form of independent certification may serve to increase the credibility of voluntary approaches vis-à-vis the consumers. Other researchers argue that the incentives necessary for the adoption of voluntary approaches to food safety may come from the modern retail system. In particular, supermarkets are seen as actors who are able to impose food safety in food networks. They develop private standards as substitutes for non-existent or inadequate public standards in order to compete with the informal sector by claiming superior product attributes (Reardon & Timmer, 2005). The private incentives for food safety created by supermarkets are primarily incentives in terms of market access, sales volumes and potential premium. Codron, Giraud-Héraud, & Soler (2005) show that the commercial risk represented by the supermarkets constitutes a strong, private incentive against which the firms try to protect themselves by developing voluntary measures in order to increase the safety level and hence preserve the commercial relationship.

III. Institutional Framework, Pesticide Residues and Food Safety Initiatives in Vietnam and Hanoi Province

Until the late 1980s, Vietnam followed the Soviet model of central planning. Agricultural production was organizsd into cooperatives and state farms (Wolz & Duong, 2009). In 1986, the market mechanism was introduced, with the adoption of a renovation policy called '*doi moi*', and farmers were given back the right to control the land and to decide how to produce, although the land remained under State ownership. With the adoption of the Cooperative Law in 1997 (revised in 2003) the old cooperatives were to be transformed into membership-oriented service cooperatives, and new agricultural service cooperatives could be established from scratch (Wolz & Duong, 2009). Nowadays in Vietnam, the bulk of agricultural production still takes place in FOs that can be broadly separated in two categories according to their size (which is itself correlated with their age and commercial orientation). The transformed cooperatives have maintained a rather large membership base (between 200 and 2,000 members) and the main focus is still on paddy production. Often, the producers making up these cooperatives share a specific interest in one production activity, such as fish or vegetable production, and are associated in smaller organisations (between 10 and 250 members), while still being officially members of the transformed cooperative. Finally, new cooperatives are characterised by a small number of members (between 10 and 60), focus on only one production activity and are considerably more commercially oriented than the other types of FOs. Each FO is administered and supervised by a management board, whose size is generally proportional to the size of the membership base: one to three persons working on a part-time basis in smaller groups, and three to seven persons either working on a part-time basis or employed as specialised full-time staff in larger groups.

The *doi moi* policy and the Cooperative Law resulted in an impressive growth of agricultural production. Furthermore, in the last two decades, the spectacular economic development and rapid urbanisation have led to an increase in the demand for more diverse and better quality products, especially in urban areas (Figuié, Bricas, Than, & Truyen, 2004). Between 1995 and 2005, vegetable production area and volume increased by 60 per cent and 81 per cent, respectively (FAOSTAT, http://faostat.fao.org/default.aspx?lang=en). Vegetable production became not only a critical component of subsistence systems in more remote and impoverished communities, but also a key industry in specialised peri-urban areas (IFPRI, 2002). Currently, the bulk of the vegetable supply to Hanoi is produced in peri-urban districts (Moustier, Figuié, Loc, & Son, 2006). Due to the very limited farm size, vegetable growers began to increasingly rely on large quantities of chemical inputs in an attempt to boost their productivity. Between 1991 and 2007, pesticide use in Vietnam increased from 15,000 to 76,000 tons (Hoi, Mol, Oosterveer, & Brink van den, 2009a). Low-cost pesticides (organophosphates, carbamates and pyrethroids) with high toxicity (WHO classes I and II) are very commonly used and application rates are much higher than the recommended rates (Dinham, 2003). The overuse of pesticides, the use of banned pesticides and the lack of compliance with the prescribed isolation time between spraying and harvest are the main causes for high pesticide residues in the marketed vegetables (Tixier & De Bon, 2006).

Currently, pesticides occupy a major place among the food safety concerns in Vietnam. Figuié and Moustier (2009) argue that the main food safety concerns, except during periods of crisis such that of avian influenza, relate to pesticide residues in fruits and vegetables and antibiotic residues in meat. More than 80 per cent of consumers interviewed in Hanoi mentioned concerns about food risk associated with pesticide use on vegetables (Figuié, 2003). In 2002, more than 7,000 cases of food poisoning from pesticide residues were reported in Vietnam, involving over 7,500 people and causing 277 deaths (Hoi et al., 2009a).

In response to rising public concern about food safety, the Vietnamese government began to seek to ensure the higher safety of foodstuffs. While, according to the law, food business operators are legally responsible for the safety and hygiene of the food they produce and trade, the government is directly involved in the enforcement of safety standards (SRV, 2003). With specific regard to pesticides, the main responsibility is given to the National Plant Protection Department (PPD), a division of the Ministry of Agriculture and Rural Development (MARD). PPD is in charge of such things as inspecting farmer fields and implementing pesticide residue control on sampled products. However, concern remains around inconsistent and inadequate surveillance and enforcement and a high level of corruption among inspectors (World Bank, 2006). Furthermore, in the case of violation, applied sanctions, if any, are not clearly defined and are rather weak (Son & Anh, 2006).

Given the cost and institutional difficulties in controlling all vegetables, the authorities have preferred to concentrate on the development of a segmented domestic market for safe vegetables, in the expectation that quality development would spread to all chains in the longer run. This choice represents a shift from a state *command and control* approach towards a stronger reliance on *'self-regulatory'* or *'market-based* approaches' (Hoi, Mol, & Oosterveer, 2009b, p. 381). Beyond launching the so-called safe vegetable programme in order to promote IPM in pilot production regions, public authorities have delivered, since 1995, a 'safe vegetable production' certificate to individual firms or farmer cooperatives that meet specific conditions and adopt IPM practices, as defined in specific training sessions. The certificate is issued by PPD to individual firms or cooperatives (and not to the individual member) and may refer to the whole land holding or to a specific plot. Issue and renewal (every three years) of the certificate is conditional on the control of chemical and pathogen residues in soil, irrigation water and sampled vegetables. As of May 2009, in Hanoi province, the total certified area amounted to 243 ha, while 40 units had obtained the certificate (33 farmer cooperatives and seven individual firms).[3]

While traditional buyers (mainly local collectors and wholesalers who usually purchase directly from individual farmers) are not yet very concerned about the safety of the vegetables they trade (Hoi et al., 2009b), new players, such as supermarkets, canteens and semi-public companies, are gradually getting engaged in vegetable safety management. These buyers are claiming to be the most demanding in terms of food safety and the most involved in checking the production process (through field inspections) and the produce supplied (through laboratory analysis). They mainly purchase through FO management boards, often require the certificate and usually pay 20 to 30 per cent (sometimes up to 100 per cent) more than the traditional market (Son & Anh, 2006). Because the demand of those buyers is unable to absorb all that is produced in certified areas, a lot of 'certified' vegetables often end up being sold on the traditional market without any price premium.

Vietnam provides an excellent field for studying the conditions for success of collective action in producing and marketing safe vegetables. On the one hand, FOs have been the main target of public programmes for safe vegetables (IPM training, certification, labelling and communication). On the other hand, despite more than a decade of hard work by the Vietnamese authorities and market actors to increase the safety of vegetables, the abuse and misuse of pesticides remains a major problem in intensive peri-urban vegetable systems and pesticide residues are a source of great concern for consumers. Without denying the benefits of collective action as measured by farmer incomes, our study aims to explain the efficiency of collective action, using as a criterion the level of pesticides on the produce and as determinants different sets of variables, internal and external to the FOs.

IV. Conceptual Framework, Research Question and Hypotheses

For the purpose of this study, the outcome of collective action is the FO's effectiveness in producing safe vegetables. The collective action problem we refer to is the issue of free riding, the opportunistic behaviour that might occur when members produce and sell vegetables with excessive pesticide residues, those sprayed with prohibited pesticides or harvested in defiance of the prescribed spray-to-harvest interval. When such a case occurs (if detected), buyers or public authorities will suspect the group of not properly controlling individuals within the group. The consequence for the FO may be a loss of reputation and possible sanctions, such as a decrease in or a cut-off of the volume to be traded, more stringent control of future transactions, administrative fines and/or withdrawal of the certificate, if it had one. In Vietnam, where most marketing structures have no traceability system at all, sanctions cannot be transferred to the individual farmer and consequences for the group are all the more high.

Free-riding behaviour can emerge as a consequence of the contrasting interest of the farmer and the FO to which he belongs. On the one hand, the individual farmer would act out of self-interest, rationally seeking to maximise his individual gain rather than to achieve the common goal. Hence he would use an amount of pesticide that guarantees higher yield, better-looking vegetables and a relatively inexpensive insurance against pest damages and crop losses, without taking into account the possible consequences on the whole FO. The lack of selective incentives within the FO to reward farmers that properly use pesticides and a lack of awareness about risks for their own health, despite several cases of poisoning of field workers, do not help limit their misuse. On the other hand, the FO is expected to further the interests of its members and, hence, it would aim at producing safe vegetables in order to improve the collective reputation, increase member access to more lucrative high-value markets and limit the likelihood of being sanctioned by the commercial partners or by the public authorities.

The review of literature (Markelova et al., 2009) suggests that the outcome of collective action depends on at least three factors: (1) group characteristics; (2) institutional arrangements within the group; and (3) institutional and economic environment. This study seeks to answer the following question: What is the direction, magnitude, and relative contribution of these factors to the level of vegetable safety?

Based on literature, we have identified a subset of variables for each of the abovementioned factors and will test the following hypotheses.

1. 'Group characteristics'.

(1.1) Group size: we test the U-shape hypothesis in the estimation, using a quadratic specification.

(1.2) Kinship: we expect that FOs characterised by a higher level of kinship among members have less free riding and hence produce safer vegetables.

(1.3) Education: we expect to find less pesticide residues in FOs characterised by a higher level of member education, beneficial to the integration of training on IPM, but as stated before the effect of education is ambiguous and might lead to higher pesticide application.

(1.4) Dependence of members on vegetable production: we expect that the more the vegetable production is salient to the livelihoods of the members, the lower the toxicity level in vegetables will be because both the farmers and the management board are more likely to be interested in maintaining their reputation in the market and the established relationship with the commercial partners. Yet, it can also be argued that if the group depends heavily on producing and selling vegetables, they would be tempted to apply more pesticides to get higher crop yield.

2. 'Institutional arrangements'.

(2.1) Meetings: we expect that interaction among members may promote a sense of affiliation and the definition of shared norms and, hence, that the higher the number of meetings the lower the amount of free riding and consequently the toxicity level in the vegetables.

(2.2) Field monitoring effort: we expect that the higher the level of the management board's field monitoring effort, the safer the vegetables.[4]

(2.3) Record keeping of pesticide application: we expect to find safer vegetables if the rules of the FO require members to keep pesticide application records and the management board to perform secondary inspections of the records.

(2.4) Control of pesticides: we expect that the purchase of pesticides by or under the supervision of the management board leads to a higher level of safety, since type, amount and source of chemicals can be better controlled and specific technical advice can be provided at time of purchase.

(2.5) Technical assistance: we expect that the higher the level of technical assistance provided to the members by the management board, the lower the likelihood of pesticide misuse.[5]

3. 'Institutional and economic environment'.

(3.1) Public threat: we expect that firmer pressure exerted by the public authorities in charge of conducting field inspections of farming practices and possibly of making residue analysis increases the likelihood that FOs produce safer vegetables.

(3.2) Market pressure: we expect that the more a FO sells vegetables directly to high-value markets, namely supermarkets, canteens and semi-public companies, the lower the toxicity level found in the produce. On the one hand, these buyers may be an incentive to keep adequate levels of food safety; on the other hand, they are the most involved in checking the quality of their supplies.

(3.3) Certificate: we expect a lower toxicity level in FOs holding a safe vegetable production certificate. Firstly, because the certificate is the prerogative of FOs whose members have attended additional specific training courses on IPM; secondly, because issuance and renewal of the certificate is conditional on pesticide residue control by the public authority, and hence is evidence of past compliance with good agricultural practices in the use of chemicals; thirdly, because water and soil conditions have been controlled; and, finally, because its withdrawal would mean the loss of the opportunity to sell to more lucrative markets, hence acting as an incentive to keep adequate safety levels. However, the certificates have been obtained well before our own pesticide residue analyses were conducted, so the possession of a certificate does not directly reflect the present adherence to food safety regulations; it does partially though, which explains why we have to check and possibly correct for endogeneity.

It is worth stressing some noticeable limitations in our study. Although we have considered some contextual factors likely to affect the behaviour of FO members, namely the institutional and economic environment, we could not include in our analysis the several ecological conditions that can directly influence the toxicity level of the vegetables. For instance, different locations can have an uneven incidence of pests and diseases or be cultivated with crop varieties with a different degree of susceptibility to them. Location specificities can therefore lead to different pesticide application needs, regardless of the propensity to free ride. Pesticide residues originate both from agricultural inputs used by producers and contaminated soil and irrigation water, and hence are not completely ascribable to farmer behaviour. Several studies show how cultivation in contaminated areas or irrigation with contaminated water contribute to increasing the residual levels of unsafe substances in crops above the allowed limit (Tixier & De Bon, 2006; Toan, Thao, Walder, & Ha, 2009). Needless to say, if resources had permitted, the inclusion of spatial information in the model (for example by the use of spatial regression models) and collection of more ecological data for every FO would have improved both our analysis and the trustworthiness of our findings.

V. Data, Selected Variables and Methods

A survey was conducted in June and July 2009 on 60 FOs producing vegetables and located in the peri-urban districts of Hanoi.[6] Since we had a specific interest in understanding the role of the certification process in determining the level of food safety, the survey was intended to be exhaustive of the 33 certified FOs. Three of the 33 targets were not available for the interview. The 30 FOs without certificate were randomly selected among the 277 FOs involved in vegetable production but not holding the certificate. In this manner, we have enough observations in each group of our stratification, but, since the sample proportion is different than the population proportion, not correcting for the choice-based nature of the sample would lead to biased parameter estimates. In order to correct this sample bias we have used the weighted exogenous sampling maximum likelihood (WESML) method (Manski & Lerman, 1977).[7]

The survey consisted of two questionnaires, one for FO leaders and one for FO members. FO leaders were asked about member characteristics and the particular features of the organisation (background, activities, governance structure, local institutional and economic environment). Particular attention was paid to the different methods of monitoring farmer agricultural practices related to pesticide use. Responses were triangulated with information collected from the members (three randomly selected members for each FO).

The dependent variable in our model is the average level of toxicity due to the presence of pesticide residues. Thus, 180 vegetable samples of different crops were collected directly in the field (three samples for each FO). Sampling was taken from vegetables that were said to be ready for harvesting and sale to the market and, where the FO had a certificate, from the certified area. Collection was conducted during the hot wet season, in September and October, when farmers face more problems in controlling pests and diseases and therefore when they are likely to apply more pesticides. Due to financial constraints, it was not possible to perform gas chromatography-mass spectrometry analysis (GC-MS), an expensive method that would have allowed us to detect the specific compounds within a test sample. An alternative and cheaper solution was the rapid bioassay for pesticide residues (RBPR) method, a test developed by the Taiwan Agricultural Research Institute. Although not as reliable as GC-MS, the RBPR is considered sensitive enough to meet the FAO-WHO regulations for pesticides in vegetables (Chiu, Kao, & Cheng, 1991). This test assesses the toxicological effect of two common types of insecticides (carbamates and organophosphates) by measuring the percentage of inhibition of the acetylcholinesterase (AChE), a key enzyme in the nervous system of animals. More than 65 per cent of the most dangerous pesticides (that is, WHO toxicity class I or II) used in the research area belong to these categories (Bosch et al., 2005). The RBPR is able to measure the toxicological effect but not to distinguish if this is ascribable to the presence of an excess of pesticides or to the use of prohibited and extremely toxic pesticide formulations. Because the levels of toxicity were not found to be significantly different among the different crops collected, the average level of toxicity for each FO can be calculated as the average result of the laboratory analysis for the three samples. Thus, the dependent variable of the model is the level of toxicity proxied by the average percentage of inhibition of the AChE in the three samples (*PESTRES*).

To explain the observed variation in the level of toxicity in the different FOs, we used a regression model, according to which the toxicity level is a function of a set of causal variables, and a randomly distributed error term.

The structural equation takes the following form:

$$\begin{aligned} PESTRES_i &= certificate_i^{'}\gamma_1 + (\text{group characteristics}_{\text{i}}^{'})\,\gamma_2 \\ &+ (\text{institutional arrangements}_{\text{i}}^{'})\,\gamma_3 + (\text{institutional and economic environment}^{'}_{\text{i}})\,\gamma_4 + u_i \end{aligned} \tag{1}$$

It should be noticed that the model may be subject to endogeneity problem due to omitted variables. In such a case, the linear estimation would lead to an inconsistent estimation of γ_i (Davidson & MacKinnon, 1993; Greene, 2008). In this regard the use of the certificate as an explanatory variable is a source of particular concern since, as previously mentioned, it was not possible to measure the level of pesticide residues in soil and irrigation water. Soil and water contamination can have an impact on both pesticide residues in the sampled vegetables and the likelihood of being certified (because the certificate is conditional on satisfactory results of soil and water analyses). To deal with this problem we have proceeded as follows.

To test endogeneity, we performed the Durbin-Wu-Hausman test (the null hypothesis is that certification is exogenous). The test confirmed that the variable certification is endogenous ($p = 0.009$). Therefore, in order to correct our estimation, we had to identify instrumental variables, denoted W, which must satisfy the condition $E(u_i/W_i) = 0$. In other words, the instrumental variables have to be correlated with the variable *certificate* but not with the level of pesticide (*PESTRES*). We have identified two instrumental variables: the number of years the FO has been running for; and a dummy variable coded as one if the FO is located in an area in which the safe vegetable programme has been implemented, and zero otherwise.[8]

To test the validity of our instruments, we performed the Sargan test, which tests for over-identifying restrictions. Considering first all instruments, the result of the test showed that at least one of the two instruments was valid ($p = 0.9971$). In order to test then the validity of each of them, we went through three steps for each instrument. The first consists of extracting the residuals from the instrumental regression, where one of the instruments is introduced into the model. The second step is to introduce these residuals in the equation. The third is to test whether the variable residuals in the model are significantly different from zero. If so, the instrument can be considered as valid. Both our instrumental variables were valid.

Once valid instrumental variables were identified, we had to test if our instruments were strong, especially because of the small size of our sample. As a matter of fact, the two-stage least squares (2SLS) estimation usually performed in cases of endogeneity provides standard errors that are too small if instruments are weak (Chao & Swanson, 2005; Stock & Yogo, 2005). We performed the test of Stock and Yogo (2005), which confirmed that our instruments are weak (considering the critical values associated to this test at the 1% threshold). This result was also confirmed by the first-stage F statistic ($p = 0.0043$).

Taking into consideration the results of the previous tests, the limited information maximum likelihood (LIML) model was identified as the most appropriate. As a matter of fact, in the presence of weak instruments and in the case of small sample size, Blomquist and Dahlberg (1999) state that the LIML estimation gives '*the most reliable estimator*'.

In addition to the LIML model and in order to have a deeper understanding of the weight of each factor in determining vegetable safety, we have performed a decomposition of the variance in toxicity level by the statistically significant variables of the regression. Statistical analyses were done using the STATA 9.0 software.

The sample of 60 observations in this study permits quantitative analysis; however, it does not provide enough degrees of freedom to examine all the factors that have been suggested as influencing the output of collective action. Furthermore, certain variables could not be included in the model since they are highly correlated with each other. The independent variables used in the model are described in the Online Appendix.

VI. Results and Discussion

In Table 1 we present the weighted means and standard deviations of our variables.

The average level of toxicity found in the FOs (*PESTRES*) is 11.2 per cent; considerably lower than 25 per cent, the level considered still acceptable for human consumption according to the literature on RBPR (Chiu et al., 1991). No figure exceeds this value but we must be careful in drawing optimistic conclusions because the variable is calculated as the average level of toxicity found in the three vegetable samples collected in each FO. In fact, looking at the detailed results of the laboratory analysis, we find that 10 FOs (16.7% of our sample) show a toxicity level beyond the limit for at least one of the three samples collected in each FO. Six per cent of samples present an excess of toxicity. A first comment is that the figure is not too bad if we consider, for example, that it is estimated that in Europe, a region where technical expertise and quality control is much more developed than in Vietnam, the share of fruit and vegetable samples with pesticides in excess of maximum residue limits exceeds 4 per cent (EFSA, 2007). A second comment is that FOs are diverse in terms of pesticide residue levels and that it is interesting to relate this diversity to the differences in groups and external conditions faced by those groups.

How do the different causal variables affect the level of toxicity in vegetable samples? In Table 2 we present the results of the OLS (Ordinary Least Squares) and LIML regressions, namely the coefficients, their standard errors and the statistical significance. In order to have a better understanding of the explanatory power of the different variables, in the right column of the table we present the result of the decomposition of variance by the statistically significant variables of the regression.

By grouping the variables in the different sets previously presented, we find that the variance breakdown attributes 51 per cent and 49 per cent of the explained variance, respectively, to the variance of ‘Group characteristics’ and ‘Institutional arrangements’, while none of the variables referring to the ‘Institutional and economic environment’ are statistically significant. We argue that in our model, only ‘internal’ features of the organisation (group characteristics and institutional

Table 1. Summary statistics for the variables (n = 60)

	Variable	Unit	Mean	Std. Dev.	Min	Max
	Dependent variable					
	PESTRES	%	11.17	4.5	2.44	22.49
stage 1	*Instrumental variables for certification*					
	DURATION (W1)	No. years	9.3	3.6	0	13
	SVPROG (W2)	Dichotomous	0.29	0.46	0	1
stage 2	*Group characteristics*					
	SIZE	No. members	196,62	178,40	7	741
	KINSHIP	Dichotomous	0.27	0.45	0	1
	EDUCAT	No. years	7.17	1.43	5	12
	DEPEND	%	44.81	30.53	2.78	100
	Institutional arrangement variables					
	NMEET	No. meetings/yr	3.54	3.24	0	16
	MONITOR	FTE inspectors/ha	0.04	0.07	0	0.41
	RECKEEP	Dichotomous	0.08	0.28	0	1
	COLLPUR	Dichotomous	0.38	0.49	0	1
	TECHASS	FTE technicians/member	0.01	0.01	0	0.05
	Institutional and economic environment variables					
	PPDCOLL	No. inspections	2.12	2.3	0	9.5
	SALETRAD	%	89.9	20.12	0	100
	CERTIF	Dichotomous	0.11	0.31	0	1

Table 2. OLS and LIML regression results for toxicity level and decomposition of variance by the statistically significant variables

	OLS		LIML		Decomposition of variance
Variable	Coeff.	Std. Err.	Coeff.	Std. Err.	Weight (%)
Group characteristics					
SIZE	–.0484306***	0.01	–.0506256***	0.01	20.26
$SIZE^2$	.0000505**	0.00	.0000537**	0.00	
KINSHIP	.5885974	1.03	.6029448	0.89	
EDUCAT	1.123496**	0.40	1.11242**	0.35	30.77
DEPEND	–.0349791	0.02	–.0377367	0.02	
Institutional arrangement variables					
NMEET	–.1405103	0.18	–.1391357	0.16	
MONITOR	3.941774	11.94	4.555083	10.60	
RECKEEP	–1.007135	2.20	–.8612104	1.98	
COLLPUR	–1.503855	1.09	–1.591751	1.00	
TECHASS	–342.5204***	89.88	–353.8857***	88.21	48.97
Institutional and economic environment variables					
PPDCOLL	–.3496442	0.22	–.2864042	0.30	
SALETRAD	–.0307597	0.03	–.035803	0.03	
CERTIF			–1.175428	4.26	
Constant	16.76063**	5.26	17.66413**	5.62	

Notes: N = 60; OLS: R^2 = 56.68 per cent; F12.47 = 5.13; Prob>F = 0.000. N = 60; 2LIML: centered R^2 = 58.34 per cent; F13.46 = 4.82; Prob>F = 0.000. *,** and *** signify statistical significance at 0.1, 0.05 and 0.01 levels, respectively. ANOVA: variance explained by the statistically significant variables = 36.11 per cent.

arrangements) have a role in determining the safety level, while external forces (institutional and economic environment) do not seem to affect it.

The first factor by magnitude of contribution to the safety level is the 'technical assistance' provided by the FO staff to each member (48.97% of the explained variance). As expected, stronger technical assistance given by the FO staff is conducive to achieving a higher level of vegetable safety.

'Education' ranks second in explanatory power (30.50% of the explained variance). A higher level of education appears to be associated with lower safety. This suggests that education contributes to the awareness of the benefits of using pesticides rather than being conducive to applying IPM.

'Group size' is the third most important factor in explaining the toxicity level (20.15% of the explained variance). The result does conform to the U-shape hypothesis and suggests that higher pesticide residues may be found in both very small and large groups due to the combined effects of economy of scale and free riding. Indeed, while smaller FOs are supervised by a few people working on a part-time basis on different tasks, larger FOs have management boards consisting of a greater number of persons and often employ specialised full-time staff. In the latter, it is not rare to find staff, either full-time or part-time, assigned to only one specific duty. Not surprisingly, they have a higher level of expertise related to their specific task that can contribute to achieving better results. In particular, the presence of qualified technicians and inspectors seems to greatly enhance the likelihood of producing safer vegetables. Furthermore, while larger FOs grow vegetables more at a subsistence farming level and aim to produce different crops to satisfy the family food needs, much smaller (and recently established) FOs are more commercially oriented, focus on the few types of vegetables required by their customers and use a more intensive pattern of production, often without any crop rotation. Therefore, smaller FOs are more likely to show a higher incidence of pests and their members are more likely to apply more chemicals in order to manage pests and ensure better-looking vegetables for the market. On the other hand, very large groups might be more affected by the opportunistic behaviour of their members and, in line with Olson's (1965) prediction, be less likely to perform successful collective actions. This is reflected by the higher toxicity level in the largest FOs.

No statistically significant effect is found for the level of social capital, dependence, frequency of member meetings, monitoring effort, record keeping of spraying and collective purchase of pesticides, or for inspections by public authorities, typology of buyers and the 'safe vegetable production' certificate.

VII. Conclusions

Our paper is an original empirical attempt to explain the outcome of collective action in the field of food safety. Through a survey of 60 vegetable grower associations in peri-urban Hanoi and drawing on common-pool resources management literature, it aims to highlight the organisational and institutional conditions that enable successful collective action. The dependent variable is the level of pesticide residues on vegetable samples as measured by a quick test. Explanatory variables include classical group characteristics, the institutional setting within the group and some external factors that might influence group behaviour. Our choice of variables has been driven by context specificities as well as collective action and food safety literature. The econometric model has proved quite relevant since over half of the variance is explained, the major contribution arising from technical assistance, education and group size. However, given the small size of our sample and the peculiarities of the Vietnamese context, we cannot generalise our findings, which are of a suggestive rather than a conclusive nature.

Our findings shed light on the role of the different sets of factors, including collective action, in attaining a high level of vegetable safety and, eventually, in giving access to high-value safety-demanding markets in Vietnam. First, they suggest that a considerable part of the variance in safety level may be explained by the availability of specific and qualified staff in charge of providing adequate technical advice. In this regard, large FOs seem to be better positioned to properly assist their members. This may suggest that in-house tailor-made technical assistance provided on a continuous basis is a necessary complement to the limited and sporadic good-for-all capacity-building sessions given by public programmes. On the other hand, our results conform to the hypothesis that very large groups can be more affected by free riding (Olson, 1965) and less successful in delivering a high level of food safety.

Second, we found that FOs characterised by a higher education of the members present higher levels of pesticide residues, most probably due to the fact that education increases the awareness that pesticides can lead to greater productivity and less risks, as suggested by Qaim and de Janvry (2005). Third, the contribution of public authorities to vegetable safety remains controversial. On the one hand, the inspections carried out by public authorities do not seem to have a significant effect on pesticide residues in our sample, which can be interpreted as a result of their unreliability, poor accountability and lack of credible sanctions. Furthermore, the establishment of a certification system, a top-down process initiated by the government rather than being market-driven, has proved to be far from a guarantee of safe vegetables. On the other hand, public training programmes have increased the level of technical expertise of FO members and leaders, which might have favoured the transfer of technical support in the FOs, with a positive effect on vegetable safety.

Fourth, the typology of buyers does not seem to have a significant effect on the level of vegetable safety. In fact, we have not found statistically significant differences in pesticide residues of vegetables sold through traditional markets.

Understanding the determinants of safer agricultural production requires further investigation, which would call for the involvement of soil, water and plant protection specialists. Furthermore, this study paves the way for future research that might apply a similar methodological approach to a larger sample within or outside the country. Indeed, the small sample prevented us from including more variables in the model and thus increasing the confidence in our findings. It would be also useful to get more economic data on the costs and benefits of reducing pesticide use. Finally, it might also be interesting to compare collective and individual forms of production organisation (for example, private enterprises) in terms of safety management and performance.

Whatever follow-up is to be given to this pioneering work, some preliminary policy recommendations can be formulated on how to promote food safety in vegetable production around Hanoi. While collective action can overcome the scale diseconomies of small farmers and considerably improve their effectiveness in producing safer vegetables, the capacity to provide adequate technical assistance and monitoring within the FOs is of paramount importance. The public authorities in Vietnam should be particularly concerned about the problem of safety in the smallest and largest FOs, since the former are less endowed with the required human resources and more inclined to follow intensive production patterns due to their strong market-oriented nature, and the latter can present more serious problems related to the opportunistic behaviour of members. Specific support to increase the effectiveness and capacity of FO staff may result in enhanced ability to limit pesticide misuse. The training and technical assistance provided by the public authorities should be more consistent and tailor-made to locally specific conditions and constraints. Finally, public safety regulations should be strengthened and scaled-up at both the production and marketing levels, either through a more efficient enforcement of process and product safety standards or through the design and management of a more adequate certification system.

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Notes

1. Peri-urban areas are defined as areas located in peripheries of cities, where the city exerts an influence in terms of resources and markets (Moustier and Salam, 2004).
2. An exception is Baland and Platteau (1996), who point out that external sanctioning institutions greatly contribute to successful collective action.
3. The cooperatives holding the certification are only a small part of the total number of agricultural cooperatives in Hanoi province (according to the Vietnam Cooperative Alliance, there are around 950, 310 of which produce vegetables). Among the cooperatives holding certification, the share of land certified is highly variable, ranging from 0.5 per cent to 100 per cent. As an indication, certification has a cost of VND10 million VND (around USD550) per hectare. In order to cover this cost, FO members growing crops on the certified land are often required to pay an annual fee. These farmer organizations are more likely to provide farmers with a written production protocol that the members usually have to sign as evidence of formal commitment. Furthermore, most of them have a system of graduated sanctions in place to deal with rule violations (usually going from a warning to a temporary suspension of sale through the management board, to an administrative fine, to exclusion from the organization).
4. The internal monitoring system in FOs can take different forms. It can be mutual, in that the members control each other; it can be delegated to hired third-party inspectors; or it can be responsibility of the FO staff. We have focused only on the latter, since the survey could find neither hired external inspectors nor any form of structured mutual monitoring that could be measured by an indicator.
5. Again, no cases of hired external technicians were found during the survey and thus the focus was exclusively on assistance provided by the FO's staff.
6. The districts are: Dong Anh, Gia Lam, Soc Son, Thanh Tri, Hoai Duc, Long Bien and Tu Liem.

7. Using the same number of observations within each group of the stratification has been done in several studies (Hindsley, Landry, Bin, & Vogelsong, 2007; Pitt & Khandker, 1998). The WESML (Weighted exogeneous sample maximum livelihood) method considers a weight, *w(i)*, equal to the population proportion, *H(i)*, divided by the sample proportion, *Q(i)*. Hence:

$$w(i) = \frac{H(i)}{Q(i)}.$$

8. The length of FO existence is statistically significantly different between certified and non-certified ones (at a 99% confidence level). In fact, in Vietnam, the more recently-established FOs are usually characterised by having wealthier membership and have often been formed to specifically market vegetables, which translates in being more likely to be certified.

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