Gender and Experimental Measurement of Producers Risk Attitude towards Output Market Price and its Effects on Economic Performance

Aifa Fatimata NDOYE NIANE, *PhD*

Agricultural Economist, Agriculture and Rural Development Sector, Dakar Regional Office, The World Bank. Email: andoye@worldbank.org

Kees BURGER, *PhD*

Associate Professor, Development Economics Group, Wageningen University, The Netherlands. Email: kees.burger@wur.nl

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Abstract

Agricultural production typically is a risky business. Farm households have to tackle several risks. So, farm households' risk attitude is an important issue connected with decision-making and greatly affects their economic performance. Particularly in Senegal, for horticultural households, output market price is one of the foremost risks. Moreover, within the household, husband and wives may behave differently towards risk. This research provides theoretical and empirical evidence of the measures and effects of risk attitude on economic performance and on the choice of inputs across gender. More precisely, based on an experimental game implemented in the Senegalese Niayes Zone, this paper investigates the gender dimension of risk attitude and the causal relationship between risk attitude and allocative inefficiency of the choice of inputs.

The results show that on average male and female producers display absolute risk aversion towards the output market price, and that women are as risk averse as men. As expected, and in line with the theoretical model, the empirical evidence shows that allocative inefficiency in the use of inputs increases with risk aversion. We identify recommendations for policy decision makers in terms of strategies which may help to dampen men and women producers' risk aversion towards output market price and repercussions for efficiency.

Key words: *risk attitude, output market price, gender, allocative inefficiency, inputs, horticultural household.*

JEL codes: D1, D4, R2

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1. Introduction

Risk can be defined as unsure consequences or an exposure to potentially unfavourable circumstances (Smith *et al.*, 1999). By definition, risk is something undesirable (Smith *et al.*, 1999). Risk is different from uncertainty, which reflects an imperfection in knowledge without any particular value assessment about the consequences. While the probability of the distribution of outcomes related to risky prospects may be known sometimes, that related to uncertain prospects is unknown and unquantifiable, unless subjectively. Risk is related to an action and is the chance of winning or losing, usually measured in terms of probability or variance (Roumasset *et al.*, 1979).

Agricultural production typically constitutes a risky business. Farm households face a variety of risks. Among them, Newbery and Stiglitz (1981) have distinguished two main categories:

- A production risk due to weather variability, pests and diseases, other environmental hazards such as inundation, drought, hurricanes, frost, et cetera;
- A price risk, particularly regarding the output price, which impacts upon the producer's decision making and income.

Most agricultural economists would agree that the producers' attitude towards risk determines their decision making, particularly in developing countries characterized by a high risk, a low income, and few risk-spreading options (Newbery and Stiglitz, 1981). Not only is the risk higher in poor rural economies, affecting farm households in several and profound ways, but poor farm households also lack the possibilities to deal with risk (Fafchamps, 2003). With limited access to credit and insurance markets, it becomes difficult to manage or cope with risk efficiently. While some wealthy households can find strategies to cope with risk and its consequences, like income volatility, through the use of their savings or through borrowing money, poor farm households only have recourse to defensive portfolio strategies to smooth their income and assets (van den Berg *et al.*, 2009).

Attitudes towards risk may not only be caused by poverty, but may contribute to maintain and emphasize poverty as well. As analysed by Morduch (1994), households may sacrifice their expected income in order to cope with risk through, for instance, a diversification of their crops or activities even if these are less profitable, but at least more free of risk. Such coping strategies provide short-term protection at a long-term cost (Abreha, 2007). To cope with risk, low-income households would opt for satisfying their current consumption by selling their productive assets and, consequently, by forgoing their expected future income. Such inappropriate or inefficient risk-coping strategies may lead to chronic or persistent poverty and an increase in the households' vulnerability. A producer's attitude toward risk and coping strategies should be a serious concern for poverty alleviation and economic development, particularly in developing countries.

Extensive research has shown that farmers are risk averse (Binswanger, 1980; Rosenzweig and Binswanger, 1993; Smith *et al.*, 1999; Senkondo, 2000; Kumbhakar, 2002; Gomez-Limon *et al.*, 2002; Fafchamps, 2003; Just and Pope, 2003; Wick *et al.*, 2004; Brons, 2005; Simtowe, 2006; Abreha, 2007; van den Berg *et al.*, 2009). These studies attempted to explain risk attitudes from individual socio-economic characteristics, such as wealth or income, family size, education, age, and gender. There is a mixture of evidence on the relationship between risk behaviour and these variables. Especially with regard to gender, while Binswanger (1980), Senkondo (2000), Simtowe (2006), and Cramer *et al.* (2002) have found that it does not significantly affect risk attitude, other authors (Wick *et al.*, 2004; Brons, 2005; Senkondo, 2000; Croson and Gneezy, 2008; and Borghans *et al.*, 2009) have found that women are more risk averse than men. Croson and Gneezy (2008) have tried to explain the gender difference in risk behaviour by the gender dissimilarity in emotional reaction, in overconfidence, and in the interpretation of the risk as a challenge or a threat. Accordingly, gender and risk aversion remain an interesting research issue.

Methodologies used to provide empirical evidence of individuals' risk attitudes can be classified into two main categories: econometric and experimental approaches. The econometric approach, mainly based on utility function or expected utility maximization, is criticized for overestimating risk aversion, confounding risk behaviour with other determinants, such as the resource constraints faced by decision makers (Wick *et al.,* 2004; Just and Pope, 2005). This is particularly important in developing countries that are characterised by imperfect markets and, as a result, by the non-separability of production and consumption decisions (Sadoulet and de Janvry, 1995; Wick *et al*., 2004). For these reasons, in this study, we adopted the experimental approach to elicit the producer's attitude toward risk. The experimental approach is rooted in hypothetical questions regarding risk alternatives or risky games with or without real monetary payoffs (Binswanger, 1980; Wick *et al*., 2004; Brons, 2005). Obviously, for any approach, one must be careful about interpreting agricultural choices or decision making as strong evidence that risk aversion is the primary explanation. To better understand the magnitude and implications of risk aversion, attention must be paid to the technical, physical, social, and financial structure of agricultural production and the inter-temporal dependence of income shocks and marginal utilities (Just and Pope, 2003).

In sum, attitudes toward risk are an important issue associated with farm households' behaviour, and may affect farm performance. Particularly in Senegal, for horticultural households, the market or output price is a major risk due to its high volatility. Although there is extensive theoretical literature on output price risk, the empirical evidence is relatively scarce contrary to that regarding production risk, which is the subject of many empirical studies, (Kumbahar, 2002). Furthermore, risk attitude may be considered as an individual characteristic. Within a household, the risk attitude may differ between the husband and wives who are managers of their separate plots, and this may have consequences for the efficient distribution of inputs among them. In addition, the optimal choices of input levels may differ, even if the underlying technology would be the same. In Senegal, within horticultural households, while men own land, have access to improved irrigation equipment like motor pump and can afford to hire labour based on a wage contract or a sharecropping contract, women usually do not. Some gender disparities occur in terms of ownership and access to productive resources.

As mentioned by Fafchamps (2003), in the context of developing countries, theory on risk behaviour is much more advanced than empirical work is. The scientific significance of this research is not only to contribute to the body of empirical evidence, but also to contribute to the reinforcement of the theoretical literature about risk attitudes. For this reason, this research aims to provide both theoretical and empirical evidence of measures and effects of risk attitudes, distinguished by gender. More precisely, this research endeavours to investigate the causal relationship between producers' risk attitude, the indicators of performance, and the decisions made regarding the choice of input, controlling for other exogenous characteristics such as age, education, gender, wealth, location, et cetera.

We will use an experimental method to address the following research questions:

- Do risk preferences differ between husband and wives, and between male and female heads of the household?
- If so, how are they related to individual characteristics and what are the consequences for the household's economic performance, and particularly for the allocative efficiency of input choice?

Allocative efficiency exhibits the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. In other words, allocative efficiency deals with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to the production value is equal to the factor cost. Consequently, taking market prices as given, allocative efficiency holds when resource allocation decisions minimize the cost, and maximize the revenue or profit.

The results show that, on average, men and women producers exhibit absolute risk aversion towards the output market price, and that women are as risk averse as men. As expected, and in line with the theoretical model, the empirical evidence shows that the allocative inefficiency in the use of inputs increases with risk aversion.

After the presentation of the background, the research objectives and questions, and the main findings through this introduction, the remainder of the paper is structured as follows. The next section will present the methodology and more specifically the experimental procedure and the theoretical models used to measure risk aversion. We will also discuss the effects of risk aversion on the choice of inputs. Then the empirical results and the discussion will follow. Finally, the conclusion and policy implications will ensue.

2. Gender issues in agricultural development

In Africa, and all over the world, regardless of the predominance of a gender bias in the access to resources, women present a vital and active force in the elaboration of a multitude of strategies that make farming and rural life economically viable and environmentally sustainable (Howard-Borjas and Rooij, 1996). Even across European countries, women farmers are far from playing passive roles; rather, they are major actors in the processes of transformation occurring in food and agricultural systems (Howard-Borjas and Rooij, 1996).

In Sub-Saharan African countries, in which on average 29% of the gross domestic product (GDP) is generated by agriculture (World Bank, 2007), women contribute about 60-80% (FAO, 1995) of the labour force used in the production of food destined for both household consumption and the market. However, due to customary norms, women's access and control over the resources of production are very limited. For instance, women's ownership and use of land is usually constrained by inheritance and land tenure laws[2]. In Africa, as a result of customary norms rather than religious rules, women are usually excluded from land ownership through inheritance in favour of men, who hold the property and hand it over to the sons within the household or to other male relatives within the extended family. Therefore, in Senegal like in most African countries, while men can inherit land from their parents, such is usually not the case for women, who get allocated just a portion of land by their husband, with a right of use rather than a right of ownership. For this reason, many African women's customary land rights are insecure; these usually depend on their marital status and can be lost after a divorce from or death of the husband (Joireman, 2008; Koopman, 2009).

Over all the continents, women own and control far less land than men do (Deere and Doss, 2006), but particularly in Africa, women rarely own land in their own right (Joireman, 2008; Koopman, 2009). However, throughout Africa, many countries like Senegal have reviewed some of their legislation related to land use and ownership rights in order to attain a better gender equity. Nevertheless, customs and a lack of information still prevent women from getting access to land, despite some improvements made on the gender equity regarding land use rights. Therefore, until now, these improvements have not been very effective.

Evidence has shown that agricultural production can be improved through equal access to production factors for men and women (Alderman *et al.*, 1995; Quisumbing, 2003; Koopman, 2009). Inequality between men and women, or gender disparities, limits economic growth and favours poverty. For this reason, one of the main objectives of the Millennium Development

[2] http://www.fao.org/Gender/en/agrib3-e.htm .

Goal (MDG), aimed at reducing poverty and stimulating growth[3], is to promote gender equality and women's empowerment. In Senegal, for instance, a National Strategy for Gender Equity and Equality (SNEEG) has been elaborated in order to promote gender equality. The SNEEG will permit the development of tools and methodologies of gender analysis, the implementation of programmes that aim to reinforce the capacity of actors in terms of the promotion of gender equity and equality, the promotion of the elaboration of gender-sensitive budgets for the different economic sectors, the reinforcement of the decentralisation of funds for the economic promotion and support of women's activities, and the reinforcement of women's leadership capacity (DSRP 2, 2006).

Yet, it still remains a challenge to improve women's agricultural performance by improving their access to land, to inputs such as seeds, fertilizers and pesticides, to credit, to extension services, and to better technologies, like labour-saving technologies and improved irrigation equipment. Women can do much better if their gender-specific constraints related to access to land and technology are addressed, and if they can enjoy the right and the economic incentives to farm their own plots (Koopman, 2009). The key importance of women in the agricultural sector in many parts of the world, and particularly in agriculture-based countries in Africa, calls for urgent attention for a more gender-sensitive policy, allowing for gender-specific production constraints and priorities.

Particularly at the household level, an economic analysis based on a gender perspective is the way to shed light on the differentiation between men and women as economic agents who behave differently and specifically, in terms of risk attitude. Regarding access to resources within the household, gender inequality arises with an array of social and economic implications.

[3] The World Bank : http://go.worldbank.org/NMIS5MXCH0 .

Farm households involved in the horticultural supply chain in Senegal, in West Africa, provide a convenient context to illuminate such gender issues in agricultural development. Usually, in Senegal, within horticultural households, both men and women or husbands and wives manage their separate horticultural plots. In this role, they may show different preferences or behaviour, notably towards risks. Such differences may have an effect on their economic performance and particularly on their efficiency in the allocation of inputs; thus, they need to be measured and accounted for. By providing theoretical and empirical evidence on these issues, this paper intends to make a scientific contribution to the gender and economics literature.

3. The study area

We have carried out the research in Senegal, in the Niayes Zone, which is the band surrounded by the Atlantic Ocean and located along the axis Dakar – Saint-Louis Regions (see the map in figure 1). We have chosen the Niayes Zone as research area because it constitutes, together with the Senegal River Valley, an agro-ecological zone of Senegal that is excellently suited to horticulture. The Niayes Zone is still the leading horticultural production zone and is the best example in terms of an integrated use of favourable factors of production and marketing (Matsumoto-Izadifar, 2008). About 80% of the national horticultural production comes from the Niayes Zone. This horticultural vocation is conferred by numerous potentialities related to favourable climatic, soil and hydraulic conditions as well as by the proximity to the urban markets. In fact, its tropical and sunny climate is marked by a great maritime influence. The average temperatures, ranging from 22^{o}C in January and 31^{o}C in October, are favourable to horticultural production. They are relatively fresh compared to the temperatures observed in the country’s interior, a relatively consistent humidity varying between 58% in December and 83% in August, and a rainfall varying from the North to the South from 300 to 500 mm per year.

The relief of the Niayes zone is modelled with a succession of sandy dunes and depressions. The soil, characterized by a dominant sandy texture, is very favourable to horticultural crops. The hydrograph is characterized by the proximity of the water table in most of the areas and the presence of lakes, temporary basins and ponds. With its potentialities, the Niayes zone is a veritable pivot of development for horticulture. However, in some places, particularly in the south zone of Niayes, the availability of water is a limiting factor. While in the centre zone of Niayes, the water table can be reached even with a non-cemented, traditional well at a depth of one meter, in the south zone of Niayes, near Dakar, in some places, the water table is so deep that the source of water used for irrigation is that of the water corporation. It is water filtered for drinking, and for this reason it is expensive and its provision is irregular. The water constraint has caused some producers to cease their horticultural production completely, while others have only partially done so, by reducing their cropped area.

In terms of demography, in the last national agricultural census done in 1998, the Niayes Zone accounted for 35 000 rural households, distributed over 20 000 family residences and more than 750 villages (RNA, 1999).

Overall, the high volatility of the horticultural crops' market prices is one of the major risks that men and women producers face. Agricultural policies still failed to put into place strategies able to stabilize horticultural prices and producers have very limited access to post harvest technologies. When producing, men and women cannot reliably predict the price at which they will sell their crop. The market price fluctuates a lot from one month to another (table 1) and even from day to day. This high market price volatility impacts upon the horticultural revenue of the farm households. Even if the yield achieved per hectare is high, if the output market price is low, the revenue derived from the production will be low, too. Moreover, producers choose the amount of labour and non-labour inputs given the uncertainty of the output market price. Consequently, the way in which horticultural producers behave toward the output market price risk may influence their decision-making with regard to the choice of inputs and may affect their economic performance. Therefore, the attitude of male and female horticultural producers toward the output market price is an important issue to take into account while investigating their economic performance. For this reason, men's and women's behaviour toward the output market price risk and its implications for their economic performance are of particular interest in this paper.

Table 1: The volatility of horticultural crops' market prices in case of tomato and cabbage.

Period	Crops' market prices (FCFA/kg)[4]	
	Cabbage	Tomato
September 2006	192	175
October 2006	237	162
November 2006	264	229
December 2006	355	633
January 2007	323	580

Source: my own survey over 2006-2007 in the Niayes Zone.

[4] 1 USD=485 FCFA; 1 Euro = 656 FCFA

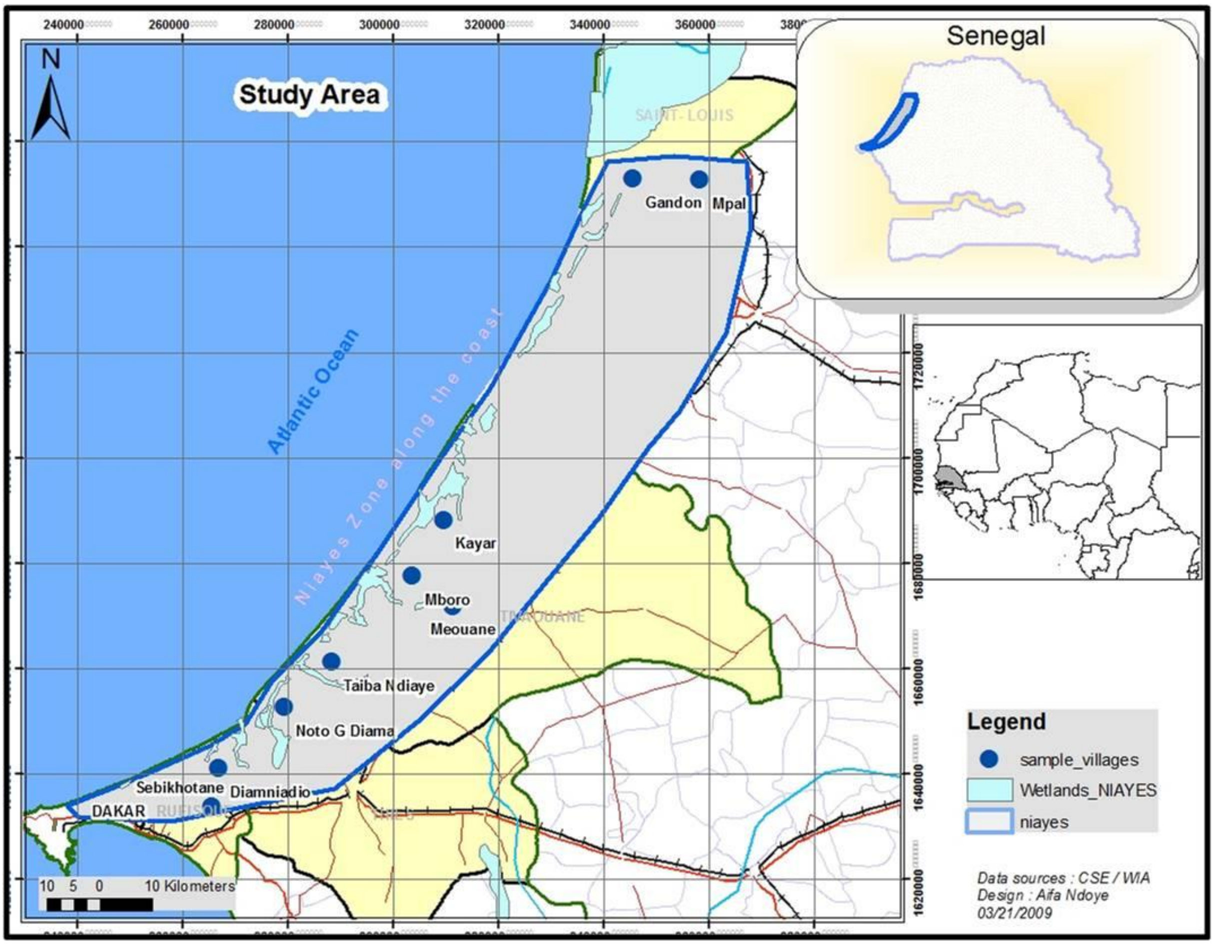

Figure 1: Map of the study area in the Niayes Zone of Senegal, West Africa.

4. The methodology

The research strategy

This research uses a quantitative focus, based on a large-scale survey of horticultural households and the implementation of an experiment to measure the risk attitude of men and women or husband and wives plot managers within the same household. A stratified and random sample of 203 horticultural households was selected in 30 villages in the study area, the Niayes Zone. This horticultural households sample is distributed over the three main subzones of the Niayes Zone and namely the Northern (42%), Central (25%) and Southern Niayes Zone (33%). The stratification was based on subzone, villages and gender. Based on a list of the villages classified by subzone and district, a sample of 30 villages was selected randomly and proportionally to the subzone size. In each village, 6-7 horticultural households were sampled randomly but also in a stratified manner, in order to include horticultural households headed by both men and women. In each village, household heads were listed and classified into different groups, based on gender. As much as possible, we randomly selected the same number of households (by lottery) in each group. In each horticultural household, we surveyed all the male and female managers of horticultural plots. On these plots, men and women produce the same horticultural crops and mainly onion, cabbage, and tomato. In this way, we surveyed a total of 285 plot managers, including 186 men and 99 women from 203 households. However, because of some missing values, the sample size varies a little across some tables but this is not an important issue.

The survey was conducted based on a questionnaire which was administrated by ourselves with the support of some enumerators trained before the starting of the survey.

The experimental design and procedure

After the completion of the questionnaire, the experimental game of the measurement of risk attitude towards the output market price was implemented separately for each man and woman plot manager within the household, to avoid any influence between household members. Given the current range of output market prices in the village or surrounding zone, and given the horticultural crop currently in production in the field (mainly cabbage, onion, tomato), we presented a "risky market A" with uncertain output prices of P_{A1} and P_{A2}. P_{A1} is the low uncertain output price and P_{A2} the high one; each output price has a probability of occurrence of 50%, like a standard gamble. This was explained to the respondents as being similar to tossing a coin (head or tail). Another alternative "risk-free market B" was defined, with a certain price of P_{Bi}, varying between P_{A1} and P_{A2} ($P_{A1} < P_{Bi} < P_{A2}$). Then, we asked the producers on which of the two markets they would prefer to sell their production if they were to harvest it today. The game started with either a high or a low price P_{Bi} and accordingly, the certain price P_{Bi} was gradually lowered or increased until the plot manager became indifferent or switched from risky market A (uncertain prices P_{A1} and P_{A2}) to risk-free market B (certain price P_{Bi}), or the other way round. The output price P_{Bi} at which the producer becomes indifferent or switches from one market to another corresponds to the certainty equivalent price P_E of the respondent.

The objective was to implement a real game with real payment, but due to the limited research budget, this was not possible. Nevertheless, lots of efforts were made to bring producers to imagining themselves as being in a real situation, so that one could suppose the same results would come up if there would be any real payment. Before starting, we explain a lot the game to make sure that the producers understand well what we are looking for. We administrated ourselves the experimental game to warrant its reliability and to avoid any misunderstanding that may arise by using enumerators. The game was administrated in the village, at home or at field depending where the producer was. The local language (Woloff) that we all speak was used and there were no need for translation. The producers showed great interest and understanding; they thoroughly enjoyed the experiment, which they found very innovative.

5. The theoretical model

5.1. Modeling risk attitude

Within horticultural households, men and women plot managers face an output market price risk. When producing, neither the men nor the women can predict perfectly at what price they will sell their crop after harvesting. The market price fluctuates a lot and impacts upon the horticultural revenue. Even if the yield per hectare achieved is high, if the output market price is low, the revenue derived from the production will be low, too.

Considering the experiment we did with two alternative markets:

- Risky market A with uncertain output prices P_{A1}, with a probability of occurrence 1- α and output prices P_{A2}, with a probability of occurrence α
- Market B free of risk, with a certain output price P_B with a probability of occurrence 1.

Following the method of Newbery and Stiglitz (1981) and Cramer *et al*. (2002), the expected utility of the producer when choosing certain market B or uncertain market A is given as:

$$E(U_B) = U(P_B) \tag{1}$$

$$E(U_A) = \alpha U(P_{A2}) + (1-\alpha)U(P_{A1})$$
$$E(U_A) = \alpha U[P_B + (P_{A2} - P_B)] + (1-\alpha)U[P_B - (P_B - P_{A1})]$$

where U is the utility function of wealth and P_{A2} - P_B is the additional benefit won when the producer chose to sell the production on risky market A and was lucky to get the high output price P_{A2}, whereas P_B - P_{A1} is the loss when the producer got the low price P_{A1}.

The second-order Taylor series approximation gives:

$$\begin{aligned} E(U_A) &= U(P_B) + [\alpha(P_{A2} - P_B) - (1-\alpha)(P_B - P_{A1})]U'(P_B) + \\ &1/2[\alpha(P_{A2} - P_B)^2 + (1-\alpha)(P_B - P_{A1})^2]U''(P_B) \end{aligned} \tag{2}$$

At the equivalent output price P_E from which the producer is willing to shift from uncertain market A to certain market B or vice-versa, the expected utility of the uncertain output market price $E(U_A)$ is equal to the utility of the certain or risk-free output market price $U(P_E)$, so that equation 2 becomes:

$$\begin{aligned} U(P_E) &= U(P_E) + [\alpha(P_{A2} - P_E) - (1-\alpha)(P_E - P_{A1})]U'(P_E) + \\ &1/2[\alpha(P_{A2} - P_E)^2 + (1-\alpha)(P_E - P_{A1})^2]U''(P_E) \end{aligned} \tag{3}$$

So,

$$[\alpha(P_{A2}-P_E)-(1-\alpha)(P_E-P_{A1})]U'(P_E)+1/2[\alpha(P_{A2}-P_E)^2+(1-\alpha)(P_E-P_{A1})^2]U''(P_E)=0$$

As defined by Arrow (1965) and Pratt (1964), two types of risk can be distinguished: absolute risk aversion (R_A) and relative risk aversion (R_R), defined as follows:

$$R_A=-\frac{U''}{U'}$$
$$R_R=-P_E\frac{U''}{U'}=P_E R_A \tag{4}$$

where P_E is the certainty equivalent price.

In simple words, in this experiment, absolute risk aversion refers to the actual amount of money a producer will choose to hold in risky market, given a certain level of output price. The relative risk aversion can be defined as the percentage of output price held in risky market, for a given level of output price.

Considering the experiment, α was set to ½, then the risk aversion scores can be deduced as follows:

$$R_A=-\frac{U''(P_E)}{U'(P_E)}=\frac{(P_{A2}+P_{A1}-2P_E)}{\frac{1}{2}\left[P_{A2}{}^2+P_{A1}{}^2-2P_E(P_{A2}+P_{A1})+2P_E{}^2\right]} \tag{5}$$

$$R_R=-P_E\frac{U''(P_E)}{U'(P_E)}=\frac{P_E(P_{A2}+P_{A1}-2P_E)}{\frac{1}{2}\left[P_{A2}{}^2+P_{A1}{}^2-2P_E(P_{A2}+P_{A1})+2P_E{}^2\right]}$$

The first hypothesis tested is whether or not men and women horticultural plot managers within the household behave differently towards the output market price risk. The review of the literature shows controversial evidence about gender and risk attitude.

5.2. Modeling the effect of risk on the efficiency of the choice of inputs

Suppose that the choice of the level of input used for production is a function of the attitude toward risk. When producing, the input price is known but such is not the case for the output price. Producers then use the input, given the uncertainty of the output market price. In this way, it might turn out that producers with a higher risk aversion use less input than less risk averse producers. Accordingly, risk aversion may have an effect on the marginal value product of the input, which should equal to the input price if allocative efficiency holds. Therefore, we conjecture that more risk averse producers are less allocatively efficient.

Based on the conventional concept of allocative efficiency, there is a non-risky efficient level of input use or an optimal level of input use for a risk-neutral landowner and this is considered as the benchmark for efficiency. However, it may be also optimal for risk averse producers to use less input when the output market prices fluctuate. Some economists would argue that these risk averse producers who choose to use less inputs are efficient, too. The traditional concept of allocative efficiency assumes certainty. Under uncertainty, the traditional measure may no longer be appropriate. We may posit that risk aversion should affect allocative efficiency.

Consider a male or female producer with a profit π derived from horticultural production, specified as follows:

$$\pi = \theta P_Y f(X, L) - wL - P_X X \tag{6}$$

Where P_Y is the output price, *f* is the output, which is a function of input X and labour L, w is the household labour opportunity cost, P_X is the input price, and θ is the random variable associated with the output price risk, with an expected value one and variance σ^2 ($E\theta=1$ and $Var\theta= \sigma^2$).

The objective of the producer is to maximize the expected utility of profit EU(π), defined as:

$$\text{Max}\, EU[\theta P_Y f(X,L) - wL - P_X X] \tag{7}$$

The producer has to optimize production, by choosing an amount of input X, so that:

$$\begin{aligned}
&\frac{\partial EU(\pi)}{\partial X} = 0 \\
&\Leftrightarrow E\{U'[\theta P_Y f(X,L) - wL - P_X X][\theta P_Y f_x^{'} - P_X]\} = 0 \\
&\Leftrightarrow EU'(\pi)\theta P_Y f_X^{'} = EU'(\pi) P_X
\end{aligned} \tag{8}$$

As P_X, P_Y and f_X' are non-random, the equation becomes:

$$\begin{aligned}
&P_Y f_X^{'} EU'(\pi)\theta = P_X EU'(\pi) \\
&\Leftrightarrow \frac{P_Y f_X^{'}}{P_X} = \frac{EU'(\pi)}{EU'(\pi)\theta}
\end{aligned} \tag{9}$$

The left-hand side of the equation corresponds to the ratio marginal value product of input X and its price, and this corresponds to the measured indicator of allocative efficiency. The right-hand side is the ratio of the expected marginal utility of the profit over the expected marginal utility of the random profit. So, the equation establishes the relationships between the producer's allocative efficiency and the marginal utility of the expected random profit.

Furthermore, by a first-order approximation of θ (the random variable associated with the output price risk) around 1, it follows:

$$\begin{aligned}
&U'(\pi)\theta \approx \left[U'(\pi)\theta\right]_{\theta=1} + (\theta-1)[U'(\pi) + \theta U''(\pi).P_Y f]_{\theta=1} + \tfrac{1}{2}(\theta-1)^2[U''(\pi)P_Y f + \\
&U''(\pi).P_Y f + \theta U''(\pi)(P_Y f)^2]_{\theta=1}
\end{aligned}$$

where the suffix 'θ=1' indicates that the value should be taken at this point. Doing so, and using that Eθ=1 and that E(θ-1)^2=σ^2, and ignoring higher-order derivatives, we can see that

$$E[U'(\pi)\theta] = U'(\overline{\pi}) + \sigma^2 U''(\overline{\pi}) P_Y f \qquad (10)$$

With the variance σ^2 equal to:

$$\sigma^2 = E(\theta-1)^2 = E\theta^2 - 2\theta + 1 = E\theta^2 - 1$$

Then

$$EU'(\pi) = U_1^{'} + E[(\theta-1)^2 U''(\pi)] = U'(\pi)$$

Knowing the expected marginal utility of the profit EU'(π) and the expected marginal utility of the random profit EU'(π)θ, equation 9 can be written as:

$$\frac{P_Y f_X^{'}}{P_X} = \frac{EU'(\pi)}{EU'(\pi)\theta} \approx \frac{U'(\overline{\pi})}{U'(\overline{\pi}) + U''(\overline{\pi}) P_Y f \sigma^2} \qquad (11)$$

where $\overline{\pi}$ is the expected value of profits.

Similarly, U'(π)≈U'($\overline{\pi}$) + (θ-1)U''($\overline{\pi}$)PY*f*

so EU'(π)= U'($\overline{\pi}$)

Knowing the producer's risk attitude, defined by the absolute risk aversion score R_A:

$$R_A = -\frac{U''}{U'} \Leftrightarrow U'' = -U' R_A$$

Replacing U'' by its value gives:

$$\frac{P_Y f_X^{'}}{P_X} = \frac{U'(\bar{\pi})}{U'(\bar{\pi}) - U'(\bar{\pi}) R_A P_Y f \sigma^2}$$
$$\Leftrightarrow \frac{P_Y f_X^{'}}{P_X} = \frac{1}{1 - R_A P_Y f \sigma^2} \qquad (12)$$

As the relative risk aversion R_R is related to the random part of the revenues only, it is:

$$R_R = P_Y f R_A$$

Then :

$$\frac{P_Y f_X^{'}}{P_X} = \frac{1}{1 - R_A P_Y f \sigma^2} = \frac{1}{1 - R_R \sigma^2} \qquad (13)$$

This equation suggests that an allocative efficiency of inputs is a function of the producer's risk aversion and the variance σ^2 of the random variable θ associated with output market price risk.

If

$$\sigma^2 = 0 \Rightarrow \frac{P_Y f_X^{'}}{P_X} = 1 \Rightarrow f_X^{'} = \frac{P_X}{P_Y} \Rightarrow X = X^* \qquad (14)$$

then, producers choose the input in such a way that its marginal value product over input price ($\frac{P_Y f_X^{'}}{P_X}$), which corresponds to the efficiency rate is equal to unity. This means that, in this case, producers are fully allocatively efficient. The marginal product of input ($f_X^{'}$) is equal to the ratio input price over output price. This means that producers choose the optimum amount of input X*.

For the risk averse producers, the absolute risk aversion score R_A and the relative risk aversion R_R are positive. In addition, if the expected utility function $U(\pi)$ is a Von Neumann-Morgenstern utility function $U''(\pi)<0$, σ^2 is positive and $\sigma^2 R_R<1$, then it follows:

$$\sigma^2 R_R > 0 \Leftrightarrow 1-\sigma^2 R_R < 1 \Leftrightarrow \frac{1}{1-\sigma^2 R_R} > 1 \Leftrightarrow \frac{P_Y f_X^{'}}{P_X} > 1 \Leftrightarrow f_X^{'} > \frac{P_X}{P_Y} \Rightarrow X < X^* \qquad (15)$$

Consequently, risk averse producers are allocatively inefficient, which means they use sub-optimally low levels of input. When the absolute risk aversion score R_A or the relative risk aversion score R_R increases, the allocative inefficiency increases as well. In other words, the greater the risk aversion score is, the greater the allocative inefficiency is, too. On the other hand, for producers who are risk lovers, the absolute risk aversion score R_A and the relative risk aversion score R_R are negative. In that case, it follows that they are allocatively inefficient and they overuse the input, which means that they use it at a level greater than the optimum one. Only risk-neutral producers (the absolute risk aversion score R_A and the relative risk aversion score R_R are equal to zero) are fully allocatively efficient. They use the input at the optimum level to equalize the marginal value product to the unit input price.

The same theory holds for the labour input, for which the relationships between allocative efficiency and risk aversion can be specified as follows:

$$\frac{P_Y f'}{w} = \frac{1}{1-\sigma^2 R_R} \qquad (16)$$

The second hypothesis tested is that more risk averse producers allocate their inputs (fertilizers, seeds, pesticides) less efficiently.

5.3.The empirical model and estimation of effect of risk on the choice of inputs

Following Zellner *et al*. (1966), as quoted by Kumbhakar (2002), we assume that the expected output price $\overline{P}_Y$ is equal to the observed output price P_Y.

Moreover, gender-specific production functions were estimated to derive male and female producers' marginal value product of inputs. Particularly, we used gender-specific stochastic frontier production functions specified as follows[5]:

$$\log(f_j) = \beta_0 + \beta_1 \log(Plot_j) + \beta_2 \log(Labh_j) + \beta_3 \log(Labo_j) + \beta_4 \log(Input_j) + \beta_5 \log(Irreq_j) + \beta_6 Seas\_01 + V_j - U_j \quad (17)$$

where the dependent variable logarithm output per hectare (f_j) obtained by plot manager j who is a male or a female household member ($j \in \{men, women\}$) is a function of logarithms[6] of :

- $Plot_j$, the plot area cultivated in hectare,
- $Labh_j$, the household labour in hours per hectare,
- $Labo_j$, the hired labour in hours per hectare,
- $Input_j$, the aggregated cost of other inputs used (seed, pesticides, mineral and organic fertilizers) in fcfa per hectare (inputs assumed to be perfect substitutes),
- $Irreq_j$, the aggregated cost of irrigation equipment used on the plot (a motorized pump, a manual pump, wells, drip systems, sprinklers, seals, ropes, pulleys, …) in fcfa per hectare,
- Seas_01, the dummy variable horticultural season (1 = 1st season and 2nd season, 0 = 3rd season),
- V_j is the random error term assumed to be independently and identically distributed (IID) N(0, σ_v^2).

[5] This paper is part of a PhD thesis and the stochastic frontier production specification is used for the requirements of other analysis of technical efficiency in another paper.
[6] To handle the cases of plots with zero input or labour, the logarithm of the variable plus one is used: log(variable+1).

- U_j, time-invariant inefficiency effects or fixed effects measuring heterogeneity.

The variables included in the production functions are hypothesized to have an effect on the output obtained by male and female plot managers. Initially, a translog functional form was specified, but the interaction variables have been dropped because they are not significant and do not help to improve the specification. For the same reasons, other variables like plot characteristics have been excluded.

As the production function estimated is log-linear, the coefficients β correspond to the elasticity of the production *f*, observed per hectare with respect to input X:

$$\beta = \frac{\partial \log f}{\partial \log X} = \frac{\partial f / f}{\partial X / X} \tag{18}$$

So:

$$P_Y f_X^{'} = \frac{P_Y \partial f}{\partial X} = \beta \frac{P_Y f}{X} \tag{19}$$

Knowing the producer's marginal value product derived from the gender-specific production functions, the allocative inefficiency of inputs can be deduced ($\frac{P_Y f_X^{'}}{P_X} - 1$). So, the effect of the output price risk on the allocative inefficiency of input can be tested, using the following function:

$$\frac{P_Y f_X^{'}}{P_X} - 1 = g(R_A, M, S, W, L) \tag{20}$$

where:

- M is the risk perception measured in terms of the appreciation of market price predictability (1 = unpredictable). It was asked to male and female plot manager whether it is possible or not to predict the output market price for next month given the current market price P;

- S is a vector of status, including the producer's socio-economic characteristics, such as the status of the head of household, the gender, age, education, number of wives, the women's status (first wife, second wife, et cetera), the access to credit and extension services, et cetera;
- W is a vector of wealth, including the men's annual income, the women's annual income, the share of the men's off-farm income, the share of the women's off-farm income, the household's labour endowment (or household size), the household's land endowment, the plot area cropped, et cetera;
- L is a vector of location: the north, centre, or south zone of Niayes.

These variables are selected for the empirical estimation because they are supposed to have an effect on men's and women's allocative inefficiency. All the variables came from gender disaggregated data collected from own detailed household's surveys carried out on men's and women's plots managers. Comprehensive surveys allowed collecting gender disaggregated data related to land, labour endowment and the different components of horticultural household's yearly income coming dominantly from horticulture and also from non horticultural crops, off-farm activities (cattle breeding, trading …) and remittance.

Fully allocatively efficient producers choose the input in such a way that its marginal value product divided by input price, which corresponds to the efficiency rate is equal to one. Thus, the marginal value product of input divided by input price minus one (the left-hand side of equation 20) is used to capture the allocative inefficiency of inputs.

6. The empirical results

6.1. Measurement of the risk attitude toward the output market price across gender

Certainty equivalent prices

An experimental game was implemented to measure men's and women's attitude toward the output market price risk, as described in detail previously. The output market price at which the producer becomes indifferent or switches from one market to another corresponds to the certainty equivalent price P_E of the respondent. The uncertain prices range on average from 208 to 400 fcfa/kg for men and from 221 to 422 fcfa/kg for women. This small gender difference is only due to the difference of the distribution of men and women over the crops harvested and sold (cabbage, onion and tomato) during the implementation of the game. For each crop, the same uncertain output prices were applied both for men and women and defined according to the current output market price found in the village or surroundings during the experiment.

The average equivalent prices of men and women are close and are, respectively, 277 and 307 fcfa/kg. Graph 2 depicts over gender the modified minimum and maximum prices of the risky market and the modified certainty equivalent price, measured in deviation of the mean of the minimum, maximum, and equivalent prices. In other words, theses modified prices are the difference between the average output prices of risky market of all the plots managers

(population) and the output prices of each plot manager (observation) involved in the experimental game. For both men and women plot managers, some of the certainty equivalent prices show up below the X axis and others above it, showing a difference in risk attitude. The more risk averse have their certainty equivalent prices below the X axis and close to the minimum prices.

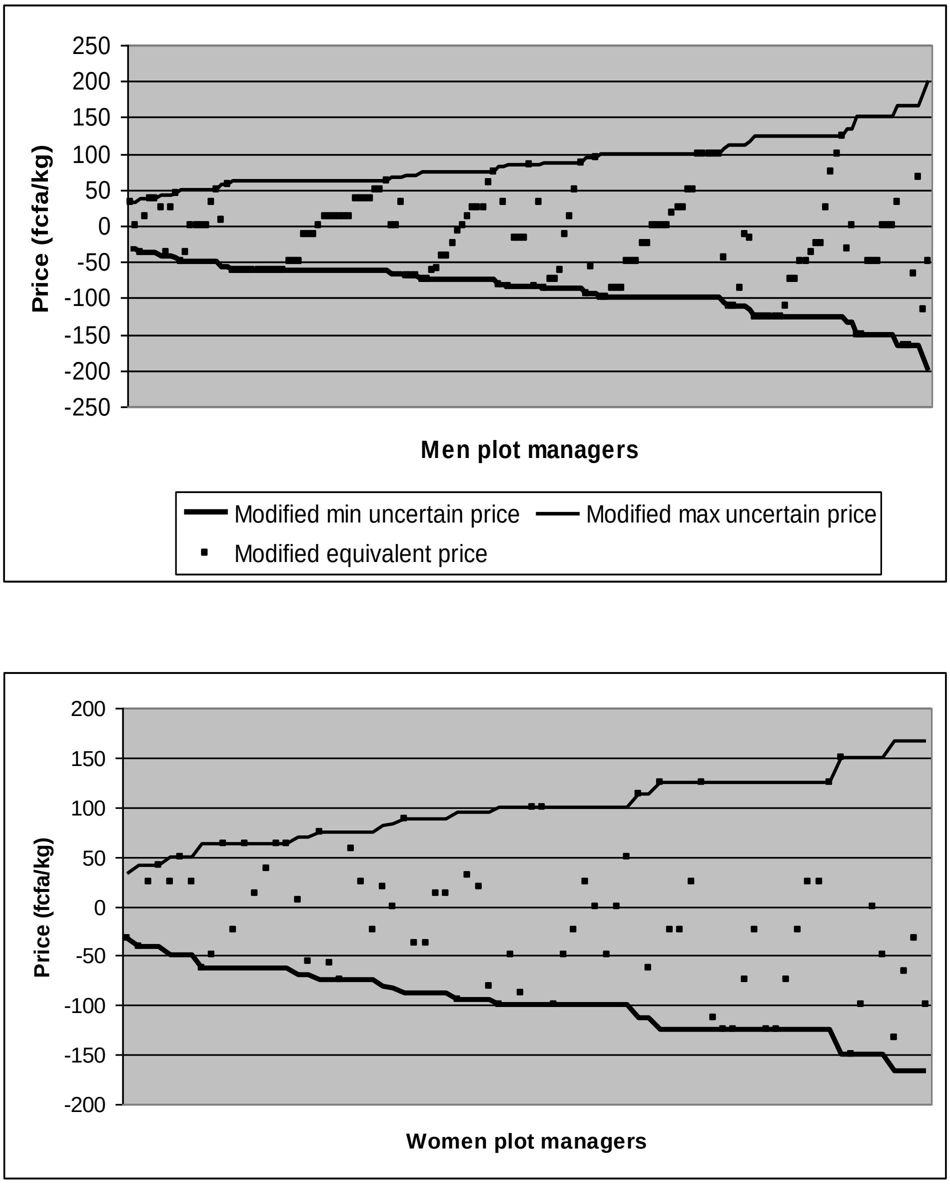

Figure 2: Modified minimum and maximum prices of the risky market and modified certainty equivalent prices over gender.

Risk aversion scores across gender

The absolute risk aversion scores (R_A) and relative risk aversion scores (R_R), derived from the equations 5, are presented in table 2. The results show that, on average, both men and women producers are risk averse, as shown by their positive risk aversion scores. The standard deviations are high, suggesting that absolute and relative risk aversion scores vary among men and women. Surprisingly, the men's risk aversion scores are greater than the women's, but the two groups' mean comparison t-test indicates that the difference is not significant even at the 10% level. This finding should not be too surprising. Indeed, women involved in horticultural production are used to going to the market to sell their own production, or through the small trading they are engaged in as an off-farm activity. For these reasons, women have as much knowledge about how the market operates as men have, and even more knowledge than men who sell their products at the field gate. This may explain why women are as risk averse as men towards the output market price. While usually in most African countries, female farmers are responsible for subsistence production while male farmers are responsible for cash crops (Bryson, 1981, Doss, 2001), such is not the case in the study area, the Niayes Zone of Senegal. In this setting, the customary arrangement is that the men are mainly responsible for feeding their family and both the men and the women are fully involved in horticultural production which is a cash crop. The staple food is mainly rice and is bought by men household-heads from their horticultural revenue.

The finding is in line with findings by Binswanger (1980) in India, Senkondo (2000) in Tanzania, and Van den Berg *et al*. (2008) in Nicaragua. They found no significant effect of gender on risk attitude, although these studies dealt with other types of risks, like risks in agroforestry decision-making, wealth, and environmental hazards. However, this finding challenges several authors, such as Kochar (1999), Byrnes *et al.* (1999), Wick *et al*. (2004), Brons (2005), Dohmen *et al*. (2005), Cohen *et al*. (2007), Croson and Gneezy (2008), and Borghans *et al.* (2009), who found that women are more risk averse than men. Croson and Gneezy (2008) have reviewed the experimental economics studies on the impact of gender on risk preference and have concluded that men are more risk-taking than women do. However, the studies reviewed by these authors are based on experiments realized mainly with students or a university population, carried out in European countries. Moreover, Croson and Gneezy (2008) have found from their review that managers and professional business persons are the exception to the rule that men take more risk than women do (quoting Atkinson *et al.* (2003), Johnson and Powell (1994), Master and Meier (1988)). Other general studies (Eckel and Grossman, 2008) have shown that attitudes towards risk between men and women vary by context. From all these evidences we can conclude that there is no clear-cut relation between gender and risk attitude; the type of risk and the cultural, social, and economic context do matter a lot indeed.

Table 2: Risk aversion scores across gender.

Gender	Obs.	Absolute risk aversion scores (R_A)		Relative risk aversion scores (R_R)	
		Mean	Std. Dev	Mean	Std. Dev
Men	160	0.0015	0.0110	0.082	2.806
Women	77	0.0002	0.0107	0.067	2.480
Combined	237	0.0011	0.0109	0.077	2.703
Difference (Men – Women)		0.0012		0.015	
t-statistic (H0 : diff. =0)		0.827 (P=0.40)		0.038 (P=0.96)	

The distribution of the risk aversion class across gender

The analysis of the distribution of the risk aversion scores reveals that more than half of the producers are risk averse, with positive absolute and relative risk aversion scores. More than 33% of the producers exhibit risk-loving or risk-preferring behaviour, as indicated by their negative risk aversion scores. Only very few producers are risk-neutral, with a risk aversion score equal to zero. The gender comparison shows the same tendency of the distribution of the risk aversion scores. However, the percentage of men ruling out risk-loving attitudes is lower than that of women, about 7%. As a result, 4% more of the men are risk averse with respect to output market price volatility in comparison to the women. Nevertheless, the differences remain statistically not significant even at the 10% level. Table 3 tells more about the distribution of the risk aversion scores and classes across gender.

Table 3: The distribution of risk aversion classes across gender.

Risk aversion class	Men		Women		Overall	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Risk averse (R_A>0)	91	57	41	53	132	56
Risk neutral (R_A= 0)	12	7	3	4	15	6
Risk loving (R_A<0)	57	36	33	43	90	38
Total	160	100	77	100	237	100

Risk attitude, individual and household characteristics

Table 4 presents the results of the regression of men's and women's absolute and relative risk attitude, controlling for all individual and household characteristics together. The results suggest that the significant determinant of risk attitude at the 5% level is only the household's land ownership. Unexpectedly, the household's land ownership has a positive effect on men's and women's risk attitude. The more a household or its men (since they are the main owners) possess land, the more risk averse men and women are. The explanation may be the land abundant households have more crops to sell, and therefore are more sensitive or careful to fluctuating prices[7]. This finding contradicts the decreasing effect of wealth on risk aversion, but is somewhat in line with findings elsewhere by Senkondo (2000) in Tanzania, and Cohen

[7] The same game was implemented for each male and female plot manager within the household. We specified not only a "risky market A" with uncertain output prices of P_{A1} and P_{A2}, and a "risk-free market B" with a certain price of P_{Bi}, varying between P_{A1} and P_{A2} ($P_{A1} < P_{Bi} < P_{A2}$) but also a fixed quantity to be traded. See section 5.2 for more details.

and Einav (2007) in Israel. However, as risk aversion is widely considered to be decreasing with wealth, this finding contradicts several evidences, found by Binswanger (1980) in India, Rosenzweig and Binswanger (1993) in India, Senkondo (2000) in Tanzania, Gomez-Limon *et al*. (2002) in Spain, Wik *et al*. (2004) in Zambia, Abreha (2007) in Ethiopia, and Van den Berg *et al*. (2009) in Peru.

Other variables that are supposed to capture the wealth effects, such as the household size, measured in terms of the number of members, and the size of the cropped area, are negatively related to risk attitude but are not significant at the 10% level. All the other socio-economic characteristics, such as the plot manager's gender and age, the household head's gender, separate female plots, and the location or zone, are positively related to attitude toward risk, but are not significant even at the 10% level. The variable education was also not significant, with a very low coefficient, the reason for which it was dropped from the regression (table 4).

Table 4: Risk attitude, individual and household characteristics (robust cluster in the household).

Dependent variable: risk aversion score of plot manager	Absolute risk aversion (R_A *100)		Relative risk aversion (R_R)	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Plot manager's gender_01 (1=female)	-0.366	0.228	-0.927	0.600
Household head's gender (1=female)	.221	0.386	0.214	1.161
Plot manager's age (years)	0.002	0.007	0.001	0.019
Household size (members)	-0.007	0.015	-0.006	0.043
Household land endowment (ha)	0.042**	0.022	0.104*	0.062
Cropped plot size (ha)	-0.354	0.413	0.093	1.048

Separate female plots (1=yes)	.121	0.196	0.354	0.490
Location or zone_01 (1=Zone Nord)	0.003	0.155	0.076	0.402
Constant	0.010	0.398	-0.525	1.064
Observations (plot managers) Clusters (households) F (8, 162) R-squared	211 163 0.85 0.02		208 160 0.61 0.03	

Note: **, * significant at the 5% and 10% level, respectively.

6.2. The effect of risk attitude on the allocative efficiency of inputs

As risk behaviour determines decision making, it may have an effect on producers' economic performance and particularly on their efficiency. For this reason, the hypothesis tested is whether more risk averse plot managers allocate their inputs (seed, fertilizers and pesticides) less efficiently. To empirically test this hypothesis, gender-specific allocative inefficiency models are used for risk averse plot managers (R_A>0 or R_R>0).

As expected and in line with the theoretical model, the regression of the allocative inefficiency of inputs shows a positive relationship with plot manager's absolute risk aversion score for both the men and women who are behaving as risk averse producers. This suggests that without controlling for any characteristic, the allocative inefficiency increases with risk aversion. The more men and women plot managers are risk averse, the more they are likely to use fewer inputs than the optimum amount given the output market price risk. The analysis of the coefficients of the regression indicates that a one unit increase in risk aversion score times 100 (R_A*100) leads to an increase by 0.79 of men's inefficiency (P=0.08) and by 0.12 of women's inefficiency (P=0.59).

Controlling for risk perception, the plot managers' socio-economic characteristics, and location, the estimation suggests that the allocative inefficiency is positively related at the 10% level to the absolute risk aversion scores of men and women who rule out risk averse behaviour (table 5). The effects of risk averse behaviour on the allocative efficiency are statistically significant at the 1% level for men and the 10% level for women. This means that the more men's and women's risk aversion scores are closer to zero (risk-neutral), the more they are allocatively efficient. This behaviour corresponds to the theoretical model's predictions, since the risk-neutral, allocatively efficient producers are the benchmark.

Table 5 gives coefficients for men of 1.22 and for women of 0.28 as far as R_A is concerned, and 0.55 for men and 2.36 for women where R_R is taken. So, women's input allocation inefficiency is much more sensitive to relative risk, and men's to absolute risk.

Moreover, for men, risk perception measured in terms of the appreciation of the predictability of the output market price is positively related to the allocative inefficiency. Perceiving the output market price as unpredictable and accordingly as a real risk, increases the allocative inefficiency, although the effect is not significant at the 10% level. For women, the effect of risk perception could not be measured because they have an almost similar perception.

In addition, the results indicate that among the variables controlled, those having a significant effect (10% level) on the inefficiency are age and location for risk averse men. The allocative inefficiency increases with the age of male plot managers. Accordingly, the younger risk averse men are more allocatively efficient than the elder men. The negative and significant correlation of the dummy variable centre zone indicates that male producers located in the centre zone of Niayes allocate their inputs more efficiently compared to those in the north and the south. Producers located in the centre and south of the Niayes Zone have more marketing opportunity because they are surrounded by big daily and weekly rural horticultural markets and are also closer to Dakar. These marketing advantages may impact positively on their output in value and, consequently, on their marginal value product and their efficiency.

Other variables such as household education, the number of wives, and access to credit have the expected negative sign for risk averse men, but do not significantly influence their allocative inefficiency. Similarly, the interaction risk aversion score and women's status as first, second or third wife is negatively related to inefficiency, but the effect is not significant at the 10% level (table 5).

On the other hand, considering relative risk aversion scores, the estimates present some similarity in terms of sign and magnitude (table 5).

Table 5: Estimation results of the effects of the producer's risk attitude on the allocative inefficiency of inputs over gender.

Allocative inefficiency	Absolute risk averse (R_A *100>0)		Relative risk averse (R_R >0)	
	Men	Women	Men	Women
Risk aversion score of plot manager (R_A *100 or R_R)	1.22*** (0.49)	0.28* (0.15)	0.55 (0.24)	2.36 (2.69)
Predictability of output price_01 (1=unpredictable)	0.56 (0.60)		0.53 (0.62)	
Age of plot manager (years)	0.04* (0.02)		0.04* (0.02)	
Household head's education_01 (1=educated)	-0.22 (0.75)		-0.20 (0.78)	
Number of wives	-0.44 (0.29)		-0.42 (0.31)	
Risk aversion * Women's status_01 (1=first wife)		-0.04 (0.24)		-1.22 (1.34)
Access to credit_01 (1=access)	-0.64 (0.51)		-0.64 (0.53)	
Plot size (ha)	0.36 (1.04)	4.79 (3.26)	0.25 (1.08)	-0.20 (8.97)
Centre zone_01 (1=Center)	-1.06* (0.58)		-0.51 (0.61)	
South zone_01 (1=South)		0.27 (0.46)		-0.69 (1.63)

Constant	-1.45 (1.37)	-0.29 (0.24)	-0.60 (1.43)	-1.89 (2.40)
Observations (plot managers) F R-squared	85 1.88* 0.16	24 1.02 0.07	85 1.03 0.09	22 0.53 0.11

*Note: ***, **, * significant respectively at the 1%, 5%, and 10% level; standard errors in parentheses, and for women or wives, robust standards errors adjusted for clusters in households to allow for an intra-household correlation (1-3 wives per household).*

Furthermore, the husband decides on the seed variety to use for 17% of the women plot managers, while he decides on the quantity and timing of mineral fertilizers and organic fertilizers to apply for 30% and 11% of the women plot managers, respectively. Accordingly, the decision maker, whether it is the woman plot manager herself or her husband and his/her risk attitude, may have an effect on women's allocative inefficiency in the choice of inputs. To test this hypothesis, the allocative inefficiency of the inputs used by women is regressed first on the dummy variable decision maker on inputs (1=women, 0=husband), second on the risk attitude of the decision maker, controlling for women's risk aversion scores or not. The dummy variable decision maker turns out not significant at the 10% level, either controlling for women's risk attitude or not. The same result holds for the decision maker's risk attitude. Accordingly, this finding shows that even if for some women, the husband decides on the use of inputs, it is likely that women always have their say and their risk attitude significantly affects their allocative inefficiency, as shown in table 5.

7. Conclusion and policy implications

Agricultural production is typically a risky business. Farm households have to tackle several risks. For this reason, farm households' risk attitude is an important issue connected with their decision-making and may greatly affect their economic performance. Particularly in Senegal, for horticultural households, the output market price is one of the foremost risks, due to its high volatility. During the production, a household can never be completely certain at which price they will be able to sell their produce later on, after harvesting. Moreover, within the same household, the husband and wives may behave differently towards risk. This research has provided theoretical and empirical evidence of the measures and effects of risk attitude across gender on economic performance and on the choice of inputs. More precisely, based on an experimental game implemented in Senegal's Niayes Zone, this paper has investigated the gender dimension of risk attitude and the causal relationship between risk attitude and the allocative inefficiency of the choice of inputs, controlling for other exogenous characteristics.

The results showed that, on average, men and women producers are absolutely risk averse towards the output market price. In addition, men are as risk averse as women are. The reason for this is that women horticultural producers are used to going to the market to sell their own produce or to engage in small trading as an off-farm activity. Consequently, women know a lot about how the market operates, at least as much as men know. This finding is in line with some other findings elsewhere, but challenges the common finding that women are more risk averse than men are. Finally, we can conclude that, depending on the type of risk measured, the knowledge or the experience about the risk and the cultural, social, and economic context, women may behave as risk aversely as men do, or even less.

Controlling for individual and household characteristics together showed that the only significant determinant at the 5% level of men's and women's risk attitude is household land ownership. The more the household or its men (since they are the main owners) possess land, the more risk averse men and women are toward the output market price. This finding challenges the common decreasing effect of wealth on risk aversion, but is somewhat in line with findings elsewhere.

As expected and in line with the theoretical model, the empirical evidence shows that over gender and risk-behaving group, and controlling for individual socio-economic characteristics and location, the attitude towards the output market price risk significantly affects men's and women's allocative inefficiency in the use of inputs (seed, fertilizers and pesticides). Specifically, the results suggest that the more risk averse men and women plot managers are, the more they allocate their inputs inefficiently. This means that the more men and women producers are risk averse, the more they are likely to use a suboptimum amount of inputs, given the output market price risk. A one unit increase in the risk aversion score times 100 of men and women with risk averse behaviour, leads to an increase of allocative inefficiency by 1.22 for men and 0.28 for women, controlling for location and individual characteristics. This increase is statistically significant. In addition, the estimation shows that other variables having a significant effect on the allocative inefficiency of inputs are age and location. The allocative inefficiency increases with the age. Producing in the centre zone of Niayes, significantly decreases the allocative inefficiency; this may be due to more marketing opportunities.

The findings resulted in a number of recommendations to policy decision makers, in terms of strategies that may help to dampen down men and women producers' risk aversion towards the output market price and its repercussions on their efficiency. Such strategies should aim at reducing and tackling, or coping with, the output market price risk.

Furthermore we can conclude, basing ourselves indirectly on the research outcomes and directly on the field observations, that to cope better with the output market price risk, men and women producers need to have access to adequate means of storage and conservation of horticultural products, which by nature are easily perishable. Being able to conserve their production may allow producers to delay and to spread the selling over time, in order to avoid an oversaturation of the market and its repercussions. Training in postharvest technologies is an important prerequisite to increase the ability of producers to preserve the quality and the freshness of the produce for a longer time. Research institutes and extension services have a lot to do to attain an efficient transference of postharvest technologies to producers. However, these measures may only have a significant effect if they are coupled with access to a suitable system of microcredit for personal consumption, which will allow producers to be not constrained to sell off their production.

At the community level, horticultural producers should be better organized in order to have more market power in relation to the middlemen traders, who used to impose their price. Some efforts should be oriented toward the reinforcement of the organization of horticultural producers. Making horticultural production zones more reachable through an improvement of the roads may facilitate producers' access to diverse markets. An efficient and daily updated system of information about the market price, accessible to producers and based on the new technology of communication (the mobile phone, for instance) may be helpful to deal with the market price risk. A smart policy of market protection may produce significant effects on the regulation of the market for some products, like onion, during the period of overproduction, while preserving the consumers' interests, too. This set of strategies needs some empirical evidence and may be a good agenda for future research.

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