Gender differences in social learning among Vanuatu cocoa growers.

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Abstract

This study analyses social learning effects among men and women in cocoa-growing households in Vanuatu. Using random matching within sample I elicit gender differences in the formation of network links, and gendered learning effects measured using a cocoa production and postharvest recommended best practice (RBPC) knowledge test. I find that information network links are determined by proximity for both men and women. Separated gender analysis highlights wide gender gaps in access to information from peers and other information channels. The results robustly show learning effects among men but not among women, and that despite women participating almost equally in cocoa production and postharvest activities when compared to men, women participated in fewer extension visits and less training activities. Women have fewer contacts within their information networks and scored lower than men in the knowledge test. Ignoring gender dynamics in the acquisition of information for the design and implementation of extension interventions can result in widening these gaps. These results have implications for the design and implementation of gender-inclusive extension strategies. Improved access to information about RBPC and effective mechanisms to disseminate this information among men and women are recommended.

Key words: gender, social learning, knowledge, agricultural technologies, cocoa, Vanuatu.
1. Introduction

Acquiring information about new agricultural technologies and how to use them has the potential to increase farmers' likelihood of adoption and to result in improvements in yields, product quality, and consequently agricultural income for rural populations. The provision of this information via extension services and other channels has the potential to benefit many of the poor in the developing world (Anderson & Feder, 2004), particularly if this information is provided to both men and women involved in agricultural activities (Quisumbing et al., 2014). However, the acquisition of information comes at a cost both to governments financing the public extension system, and to farmers who need to search for this information and devote time to acquiring it (Aker, 2011; Norton & Alwang, 2020). In this scenario women are at a disadvantage since access to extension services is consistently lower for women when compared to men (Ragasa et al., 2013). As an alternative, learning from others and the use of information networks has arisen as a cost-effective option to disseminate information on agricultural innovations (Chavas & Nauges, 2020; Norton & Alwang, 2020). Studying the effectiveness of this mechanism has become the object of several recent studies in the field of agricultural development (Broeck & Dercon, 2011; Conley & Udry, 2010; Di Falco & Bulte, 2013; Magnan, Spielman, Lybbert, et al., 2015; Matuschke & Qaim, 2009; Meador, 2019; Murendo et al., 2018; Spielman et al., 2010; Wossen et al., 2013).

Learning can take place in different manners: training, learning by doing, and learning from peers (Conley & Udry, 2010; Foster & Rosenzweig, 1995, 2010). Individuals acquire knowledge about how technologies work and their benefits from others in order to make decisions on whether to use them or not (Rogers, 2003). Some of the recent literature on adoption has focussed on the process of social learning and how it can lead to adoption. However, less has been done about the transmission of information itself, and how
knowledge about a technology and its benefits can spread within social networks. Moreover, despite the growing evidence of the key role of women in agriculture (Doss, 2013; Johnson et al., 2016; Udry, 1996), many studies focus on men and their information networks, with fewer studies looking at social learning among men and women (BenYishay et al., 2020; Dillon, 2011; Magnan, Spielman, Gulati, et al., 2015; Mekonnen et al., 2018). Several studies have found evidence of social learning in the adoption process, with early adopters providing others with information about the success or failure of different practices, thus reducing costs of experimentation with the new practice (Conley & Udry, 2010). This approach has shown that learning effects take place up to a certain point, exhibiting an inverse U-shaped relationship between adoption and the number of adopters in the network (Bandiera & Rasul, 2006; Liverpool-Tasie & Winter-Nelson, 2012; Mekonnen et al., 2018). This indicates marginal decreasing returns to additional adopters due to reduced costs for farmers compared with own experimentation. Most of these studies have focused on looking at how adoption is influenced by the number of adopters within farmers' information networks, rather than looking at the effects of information sharing on farmers' knowledge. Yet, it is also possible that there is a marginal negative effect in acquiring information about new technologies and how they work, where individuals learn from each other up to a certain point, then other factors such as experience, training and extension visits become more important. To my knowledge, a few recent studies in agricultural development look at the effects of social learning in knowledge about recommended best practices and their benefits. Some studies have used knowledge tests, specific to only a few technologies, and as an additional component in the analysis (Beaman & Dillon, 2018; Fafchamps et al., 2019). I have only found one recent study looking into the effects of information networks on knowledge about agricultural technologies (Lee et al., 2019).
This study contributes to the growing literature on social learning in agriculture. The objectives of this study are to determine whether there is evidence of information sharing about recommended best practices for cocoa production and postharvest (RBPC), to compare men’s and women’s RBPC knowledge and to identify the extent of information sharing among men and women. I use a unique data set from Vanuatu, where agricultural roles are believed to be sharply divided along gender lines: women produce and market the vast majority of food crops while men overwhelmingly produce and control the incomes earned from cash crops (UN Women, 2012), and households face trade-offs between the significant share of their labor time dedicated to cultural ceremonies and the production of local public goods and other economic and social activities (Martyn, 2015). The commodity focus of this study is cocoa, since this cash crop is the third most important source of cash income in Vanuatu, with a total of 25% of Vanuatu households involved in cocoa production (VNSO, 2016).

Specifically, this study aims at answering the following research questions: (1) What are the determinants of the formation of an information link and how these characteristics differ between men and women? (2) Is there evidence of information network effects in the knowledge of recommended best practices and are these different between men and women? (3) Is there evidence of an inverse U-shaped relationship between individual knowledge and the knowledge of information network links?

To answer these questions, I use information from a detailed knowledge test about RBPC administered to men and women, and detailed data on men’s and women’s cocoa information networks using random matching within-sample (Liverpool-Tasie & Winter-Nelson, 2012; Maertens, 2017; Maertens & Barrett, 2013; Mekonnen et al., 2018). These data are from a representative sample of the population of cocoa growers in Epi island, Vanuatu. I analyze the correlates of the formation of an information link separately for men and women using
dyadic regressions and estimate Poisson regressions to determine the relationship between men’s and women’s RBPC knowledge, measured by their test scores, and the average test scores of their information network links.

The results of this study highlight the wide gender gaps in access to information from extension services, training, and peers. The results also suggest gender differences in the formation of learning links and in learning effects. These results have implications for the design and implementation of gender-inclusive programs promoting RBPC in the Pacific, and potentially for the promotion of other agricultural technologies.

2. Women and Cocoa in Vanuatu

Cocoa is the third most important source of cash income in Vanuatu. It provides a source of livelihood for 8,500 households, with a total of 25% of Vanuatu households involved in cocoa production (VNSO, 2016). Most of the cocoa in Vanuatu is produced by smallholder farmers in the islands of Malekula, Epi, and Santo (VNSO, 2016), with these households using land and family labour as main inputs for cocoa related activities.

Cocoa production faces several challenges: pest and diseases, low availability of yield enhancing inputs, lack of market access, and increased vulnerability due to climate change (FAO, 2018). The government of Vanuatu, several international organisations and dark chocolate makers from Australia promoted interventions to improve yields and quality of the cocoa produced in the country, with most of these interventions taking place in Malekula and Santo and to a limited extent in Epi. These interventions have resulted in improvements in cocoa quality and have opened market opportunities for cocoa and dark chocolate produced on the islands. However, it is unclear how these new opportunities are affecting men and women in cocoa producing households.

The literature on agricultural roles in Vanuatu suggests they are divided sharply along gender lines, with social norms about the role of men and women in agriculture documented to be
influenced by *kastom*¹ and religion (Douglas, 2002; Wallace, 2011; “‘Women Work, Men Talk,’” 2016): women produce and market the vast majority of food crops (mostly yams) while men overwhelmingly produce and control the incomes earned from cash crops (cocoa, copra, kava) (UN Women, 2012). Women and girls are assumed to take primary responsibility for food production and family food security by growing crops in homestead gardens, rearing small livestock, and producing handicrafts. On the other hand, men are principally engaged in cash cropping, and in inter-household transfers and social activities associated with accumulating social status for the household, such as the day for the chief (Martyn, 2015). Women are mostly involved in activities revolving around the church (Douglas, 2002).

In Vanuatu there is a prevailing perception of women not being involved in cash crop production and postharvest, and that their role is somehow less significant compared to that of men. The early literature documenting men’s and women’s roles has been criticized by ethnographers who argue that male social scientists conducted most of the ethnographic work leading to these perceptions of the role of women by mostly interviewing men (O’Brian, 1984; Tiffany, 1984). In line with Boserup (2007) ethnographic studies also suggest that the transition from food to cash crop production in colonial times is to blame for this perception, and that women became a source of labour for men’s activities (e.g. cocoa and coffee production and harvesting), with their role in cash crop related activities becoming less visible when compared to their role in food crop related activities (Nash, 1984). These perceptions are likely to result in lack of engagement of women in agricultural interventions potentially putting them in disadvantage with respect to men. International organisations and

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¹ Brimacombe (2016) defines *kastom* (custom, tradition) as the wide range of knowledge, practices and traditions from an ancestral point in time up to the present day.
NGOs target women with their interventions, but it is unclear how many of these efforts are focussed in agriculture (Asian Development Bank, 2017).

3. Data

The sample design consists of purposive sampling of households that grow cocoa in Epi island. We selected these households randomly from a list provided by the Epi Cocoa Producers Association (ECPA) and the lists that we gathered with ECPA members and chiefs at cocoa-growing villages. For each household, we collected information with the names of the male head of household and the name of their spouse. The list included members and non-members of ECPA. We selected the number of households sampled in each village based on the proportion of the island’s grower population in that village.

The cocoa-growing households in our sample were members of the Epi Cocoa Producers Association (ECPA). ECPA had 130 members across 13 villages over the West Epi coast in 2018. Our lists also included 70 non-member households that were reported to have started growing cocoa in 2018. The information for these households was inaccurate, and many were not even growing cocoa. The households included in the sample were cocoa-growing households with established cocoa trees (trees bearing fruit), most of these households were ECPA members. The total sample corresponds to 118 households in nine villages in West Epi.

The survey was translated to Bislama, the local language of Vanuatu. We trained a total of 10 enumerators and two field coordinators from Port Vila, the capital city. The survey was conducted over eight weeks between September and October of 2018 on the western coast of Epi. Dates for data collection were agreed upon with village chiefs and individual

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2 This sample appears small, but according to the VNSO (2016) there were 562 households producing cocoa in Shefa province, which includes the islands of Efate, Epi and Sheppard Islands, out of those 152 were producing cocoa in Epi. The data used in this study provides detailed information about these households rarely available for Vanuatu. Collecting data in the country's islands is challenging mainly due to the remoteness of many of the islands.
appointments were made with male and female heads of household. Men and women were interviewed individually and separately, and enumerators were of the same sex as the people they were interviewing. Interviews with men and women were completed in more than one visit.

The survey included questions on farmers’ socio-economic characteristics and farm characteristics that were answered by the male in charge of managing the farm. The survey also included men’s and women’s modules on participation in cocoa related activities, social networks, detailed RBPC knowledge tests, and participation in community activities.

Our final sample contains information for 118 men and 106 women. These were all married-partnered individuals. Unfortunately, the information for 12 women was excluded because the data were incomplete.

4. Methods

4.1 Measuring networks.

For the network analysis, I used random matching within sample, which consists of asking farmers questions about others within the sample (randomly chosen, usually between five and 10). According to Maertens and Barrett (2013) this method of randomly drawing a number of individuals included in the sample and eliciting details of the relationship, outperforms matching with all the observations included in the sample. The disadvantage of the method is that it can omit important network links and result in bias of estimates. However, it is an efficient way of gathering information and allows for statistical inference (for a detailed discussion see Maertens and Barrett, 2013). I limited the network to the village. Due to the distinctive roles of men and women in Vanuatu both individually and at the group level and

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3 Statistical analysis comparing the characteristics of included and excluded women’s households resulted in non-statistically significant differences.
following local customs (*kastom*) men’s and women’s information networks were restricted to same-sex networks.

Similar to Maertens (2017) each enumerator was provided with two bags with the ID and names of the men and women included in the sample for each village. This method allows questions referring to specific individuals within the network. Each enumerator drew a name randomly for the bag and put it aside until they asked about 10 other men or 10 other women within the village sample.

In this study, information networks are defined using a similar question to the one used by Conley and Udry (2010): “Do you go to [name] for advice when you have issues with your cocoa?” (from now on *advice*). This question implies that the individual they go to is perceived as knowledgeable about cocoa RBPC, consistent with Rogers (2003) “individuals seek information and advice from those they perceive as more technically competent”. In addition to this question, we asked: "Do you discuss any cocoa production or postharvest related issues with [name]?" (from now on *discuss*), similar to the question used in other studies, to define information networks (Bandiera & Rasul, 2006; Mekonnen et al., 2018).

### 4.2 Measuring knowledge

A knowledge test was administered to men and women. The questionnaire is included in Appendix 1. The knowledge test is based on cocoa extension manuals written for the Pacific, the test was validated with an extension officer working with the Secretariat of the Pacific Community, a local extension agent in Vanuatu and 40 local cocoa growers – 20 men and 20 women who were not included in the final sample. The answer to the questions included multiple-choice, true and false statements and questions that required a specific answer.

Following Kondilys et al. (2015), enumerators were specifically asked not to read the list of

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4 We were able to collect 10 or fewer observations for three villages in our sample. In these cases, we ensure that all the matches for which we had information were included in the network analysis.
possible answers to avoid influencing respondents’ answers to the knowledge questions. Enumerators were instructed to listen carefully to respondents’ answers and mark their responses accordingly. Enumerators received training in RBPC. The training was hands-on, and enumerators visited local farms in the study site. Local farmers not included in our survey, explained the production and postharvest process in the local language (Bislama) and were asked to explain the terminology farmers use to talk about different practices. The questionnaire contains a total of 21 questions with three questions on weeding, three questions on pruning, two questions on harvesting, five questions on fermenting, four questions on drying, four questions on the management of pests and diseases, and two questions on identifying cocoa bean problems in a picture. The test was divided into four sections: pruning, weeding and harvesting, fermenting and drying, pests and diseases and ability to identify issues with cocoa beans. These sections were worth 21, 10, 11 and 16 points respectively, for a total of 58 points.

4.3 The formation of learning links

To study the correlates of network links I implemented similar methods to Mekonnen et al. (2018), Maertens and Barrett (2013) and Fafchamps and Gubert (2007) to estimate the following dyadic regression:

\[
\text{link}_{ij} = \alpha + \beta_1 (x_i - x_j) + \beta_2 (x_i + x_j) + \beta_3 w_{ij} + \beta_4 \text{village} + \mu_{ij}
\]

(1)

where \text{link}_{ij} denotes the existence of an information link between individuals \(i\) and \(j\). The characteristics of each individual \(i\) and each match \(j\) enter the regression as a difference \((x_i - x_j)\) and as a sum \((x_i + x_j)\). Where \(\beta_1\) includes the coefficients of the differences and if they are positive this implies that individuals with differing characteristics or “heterophilious” tend to form a link. According to Granovetter (2005) these network links
connect cliques tend to build bridges between dissimilar groups and convey information about innovations. The parameter $\beta_2$ includes the coefficients of the sums and if they are positive it indicates that there is positive assorting matching or that individuals with similar characteristics or “homophilious” tend to form a link (Jäckering et al., 2019), according to Rogers (2003) information flows between individuals who are alike. The vectors $x_i$ and $x_j$ include individual characteristics such as age and education, household size, frequency of participation in community activities, number of cocoa trees, household and agricultural assets and participation in cocoa related training activities and extension visits. The variables in $w_{ij}$ capture proximity variables between individuals $i$ and $j$, which are also considered to influence the formation of network links. These include whether they have neighboring cocoa fields, how often they meet, and whether they believe their contact produces cocoa. Village includes a set of village variables, and $\mu_{ij}$ is the error term. I estimate Equation 1 using Probit, separately for men and women, with advice and discuss as dependent variables. Standard errors are clustered at the individual level to control for individual correlation of the errors.

4.4 Learning effects

To estimate the men’s and women’s information networks effects in knowledge about RBPC I estimated the following specification, following the linear in means model of social interactions:

$$score_i = \alpha + \beta_1 \overline{score}_i + \beta_2 \overline{score}_i^2 + \beta_3 x_i + \beta_4 xN_i + \beta_5 village_i + \mu_i$$  \hspace{1cm} (2)

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5 I also estimated Equation 1 using the linear probability model (LPM), the results are available in the online supplementary material.
where \( score_i \) is the total test score of individual \( i \) in the knowledge test, and \( \overline{scoreN_i} \) is the average test score of \( i \)’s information network matches. I included the square of this term in the equation to test for decreasing marginal effects (inverse U-shaped relationship) among peers (Henderson et al., 1978; McEwan, 2003; Zimmer & Toma, 2000). The vector \( \mathbf{x}_i \) includes a set of individual \( i \) characteristics likely to influence individual knowledge about RBPC, such as education, experience in cocoa farming, participation in training activities and extension visits, interactions with others (participation in community activities, travel time to the nearest road), size of cocoa operation (number of cocoa trees) and wealth measured by productive and household assets indexes. \( \overline{\mathbf{x}N_i} \) denotes the average of the characteristics of information network matches likely to influence knowledge including education, experience growing cocoa, participation in training activities and extension visits, number of cocoa trees and productive assets. The specification in Equation 2 also includes quadratic terms for education and experience in cocoa farming for individuals and for their peers (McEwan, 2003). \( Village \) is a set of village variables, and \( \mu_i \) is the error term. Finally, \( \beta_1, \beta_2, \beta_3 \) and \( \beta_4 \) are parameters (and vectors of parameters) to be estimated.

Other studies have tested an inverse U-shaped relationship between adoption and the number of adopters of a technology within the information network, and argued that the existence of diminishing returns to adoption is consistent with learning effects, because observing the effects of adoption decisions on others is less costly than own experimentation. This means that individuals free ride from others’ experimentation to reduce costs, however, heterogeneity among individuals and farming systems might require own experimentation for learning, the tension between learning from others and by doing leads to the inverse U-shaped relationship. In this paper I test for learning effects or an inverse U-shaped relationship between test scores and network test scores as measures of knowledge or whether \( \hat{\beta}_1 > 0 \) and \( \hat{\beta}_2 < 0 \) in Equation 2. I hypothesise that there are decreasing returns of
learning from others, this relationship between the test scores of individuals and the test scores of their peers have been tested in other studies (Henderson et al., 1978; McEwan, 2003; Zimmer & Toma, 2000). However, as others have pointed out, it is possible that $\beta_1 > 0$ and $\beta_2 > 0$, or a positive relationship at an increasing rate due to marketing externalities can be explained by other network effects (Bandiera & Rasul, 2006; Liverpool-Tasie & Winter-Nelson, 2012; Mekonnen et al., 2018).

The estimation of social effects often suffers from problems arising from omitted variables. According to Manski (1993) these issues can arise because of correlated effects, given the propensity of individuals within the same group to behave similarly because they have similar individual characteristics. They may also arise from exogeneous or contextual effects that occur when individuals’ behavior varies with the exogeneous characteristics of the group, such as facing a similar environment or being exposed to similar conditions. I controlled for correlated effects in Equation 2, with the inclusion of the average of the characteristics of network matches likely to affect their levels of knowledge. I controlled for exogenous effects including village variables to capture differences in test scores at the village level.

Nevertheless, the study data do not allow me to control for simultaneity (Manski, 1993). In other words, it is not possible to identify whether individual test scores are likely to be higher because of network links’ higher test scores, or whether individual test scores increase network links’ test scores. Evidence of the existence of an inverse U-shaped relationship between individual knowledge and knowledge of information network links still provides relevant information about learning effects within the context of this study. To reduce concerns about the results I also conducted robustness checks by estimating regression 2 for discuss as a robustness check for advice, estimating these regressions excluding observations with the highest and the lowest test scores, and by using other network definitions.
Equation 2 was estimated using Poisson\(^6\), due to the positive and discrete characteristics of the dependent variable.

5. Results

5.1 Individual, household and farm characteristics

Individual, household and farm characteristics of the sample are shown in Table 1. It also includes two indexes used to estimate household wealth using both household assets (non-production assets) and cocoa production and postharvest assets (production assets). The index is constructed to aggregate assets while taking into consideration the differences between owning different types of assets. The methodology follows a widely used method to estimate asset indexes using principal component analysis (PCA) (Filmer & Pritchett, 2001; McKenzie, 2005). The table also includes information on participation in community activities. Men typically attend the day for the chief once a week whereas women traditionally participate in community activities organised around the church.

Table 1 about here.

The main differences in the individual characteristics of men and women in the sample are their participation in training and extension activities (see Table 1). About 25% of men participated in training activities related with cocoa in the last five-years, whereas only 10% of women did. Overall training levels were low and most of the training took place three years or more before the survey took place. In addition to this, about 48% of men participated in extension visits, whereas only 29% of women did. These activities include the ones conducted by ECPA. These results evidence the relatively low levels of provision of extension services in Epi, and how this affects women in particular.

\(^6\) I also estimated Equation 2 for advice and discuss using OLS, these results are available in the online supplementary material.
Women participate almost equally to men in most of the production and postharvest activities related to cocoa (see Table 2). With regards to production and postharvest activities, women participate less in pruning, fermenting, and selling dry cocoa beans when compared to men (the difference is statistically significant p-value < 0.10). Sales of dry cocoa beans are usually done by men, who tend to take over this activity since the prices paid for dry beans tend to be considerably higher than the ones for wet beans. In 2014, 2017 and 2018 the price for dry beans was almost three times higher than the price of wet beans (55 vatu/kg for wet beans and 150 vatu/kg for dry beans in Epi in 2018).

Table 2 about here.

5.2 Information network links

About 85% of links for men and women they reported in discuss are also links they reported for advice. Women reported fewer contacts within their information networks when compared to men, on average women reported one less contact with a neighboring cocoa plot, about two fewer contacts in their answers to advice and discuss (see Table 1). This is also the case with the number of contacts women believe produce cocoa of higher yields and higher quality (see Table 1). Detailed answers to the questions of network links can be found in the supplementary material.

5.3 Knowledge test scores

Overall men scored higher than women in the RBPC knowledge test (Table 3). As can be seen in Figure 1, most of the test scores for both men and women were below 27 points, indicating that knowledge about RBPC is relatively low, with most of the sample providing 50% or fewer correct answers. The tails of the test score distributions revealed that the highest scores were obtained by men, and the lowest scores by women (see Figure 1). Men’s and women’s test scores are presented in Table 3, and test scores of reported network links are included in the supplementary materials. Men obtained higher scores when compared to
women, and this can be seen by the differences in total score and score by topic. Except for identifying cocoa issues in a picture, all the differences are statistically significant with p-value < 0.10. There are no statistically significant differences in the results for the test scores of the reported network links.

Table 3 about here.

Figure 1 about here

5.4 Correlates of information network links

The marginal effects of network link formation for men and women after probit estimation are presented in Table 4. The results include the estimated coefficients for the differences $\hat{\beta}_1$ and the estimated coefficients for the sums $\hat{\beta}_2$ in Equation 1 where they are statistically significant (p-value < 0.10). The complete regression table is provided in the supplementary material.

Table 4 about here.

The estimated coefficients differ for men and women. The results suggest that proximity among individuals is a key determinant of the formation of information links. The probability of a network link as measured by advice increases by 34% with i passing by j’s cocoa field for men and by 15% for women, which can be interpreted as providing individuals with the ability to observe the level of skill of their network links. Meeting more frequently is correlated with a 7% higher probability of the formation of an information link for both men and women, and is likely to result in more opportunities to engage in conversation about cocoa related issues. In Vanuatu, homesteads are concentrated at the village and most village dwellers live a short distance from each other, facilitating frequent meetings. For men, the

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7 Equation 1 was also estimated using the linear probability model (LPM) separately for men and women using both advise and discuss as dependent variables. The results are very similar to the ones presented in Table 5 and are available in the online supplementary material.

8 Chi-square tests for differences in the estimated coefficients for regression 1 between men and women are Chi-square(35)=88.54 Prob>chi-square=0.00 for advice and Chi-square(35)=96.32 Prob>chi-square=0.00 for discuss.
belief that the contact produces cocoa of higher quality increases the probability of an information network link by 12%. Men oversee the sales of dry beans, which provides a high-quality price premium. Whereas women are more involved in the sale of wet beans, for which quality traits do not determine the price. Interestingly, the belief that a contact has higher yields is not significant in the formation of information links, which might be related to farmers prioritizing information on how to improve cocoa quality over yields, due to the quality-price premium.

There are no identifiable patterns in whether individuals form links with contacts who are homophilous or heterophyllous. I find evidence that individuals form network links with others with both similar and different characteristics. For example, the coefficients for the sum and the difference in education are both positive and statistically significant for men. For women, the coefficients for the sum and the difference of frequency of participation in the day for the church are both negative and statistically significant. Indicating that men tend to form information links with both more and less educated men, and women do not tend to form information links around participation in church-related activities.

5.5 Correlates of learning effects

The results from the estimates for Equation 2 are presented in Table 59. The estimated coefficients in the regressions for learning effects are different for men and women10. The effect of the information network knowledge, as measured by the RBPC test scores, is positive and statistically significant for men, but not for women. The coefficient for the average score of the network links indicates that for one additional point in the network test score there is an increase in approximately one point in men’s scores. The effect is increasing at a decreasing rate as indicated by the coefficient of the square of the average test score for

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9 Complete regression tables available in the supplementary material.

10 Chi-square tests for differences in the estimated coefficients for regression 2 between men and women are Chi-square(35)=46.47 Prob>chi-square=0.09 for advice and Chi-square(35)=50.66 Prob>chi-square=0.04 for discuss.
the information networks. This relationship suggests the existence of a learning effect that has diminishing returns given the current state of knowledge within the network. The coefficients indicate that men learn from other men up to when the average score for their network reaches 13 points for advice and 15 points for discuss, and after that, the effect of the knowledge of network members produces negative marginal returns.

Table 5 about here.

Education and experience also have a positive effect at a decreasing rate for men. Interestingly, the correlation with the frequency of participation in the day of the chief is negative, other things being equal. Larger household size and participation in extension visits also are negatively correlated with test scores for men. Participation in the day of the chief and having more household members are indicative of trade-offs between acquiring more knowledge about cocoa production and postharvest recommended best practices and participation in community activities and household obligations.

Women's test scores are not correlated with the test scores of other women within their information network. The coefficient of experience in cocoa farming indicates that for each additional year of experience test scores for women increase by 0.57 points, and that this increase only starts showing marginal negative returns after 28 years of cocoa farming experience, when test scores for women start declining by 0.01 points. For women, participation in extension visits has also a negative correlation with test scores in the knowledge test. The coefficient for this variable of -2.27 for advice and -2.23 for discuss, higher than the coefficient for this variable for men. These results have two possible but unresolved explanations: households receiving extension visits are the ones who need it most, or extension visits are promoting misinformation.

In sum, these results suggest the existence of learning effects among men but not among women. These results are robust to the use of different estimation methods, the OLS results
Robustness checks

I conducted robustness checks excluding individuals with the highest and with the lowest test scores from the sample for both information networks and proximity networks for both men and women. Table 6 presents the results when men and women in the top 10% of the distribution of the knowledge test scores are excluded – scores above 25 for men and above 22 for women. It also presents the results when men and women in the lower 10% of the test scores distribution are excluded - scores below 10 for men and below 7 for women. The inverse U-shaped relationship between individual test scores and the average test scores of information network links for men is robust to the exclusion of high and low performers in the knowledge test for advice. The results become statistically insignificant for discuss when excluding low performers from the regression but are robust for advice. I also conducted robustness checks using defining networks using the answer to the questions: “Do you pass by [name] cocoa field when you go to your cocoa field?”, pass by, and “Does [name] have a cocoa field neighbouring yours?”, neighbour, to determine network links. I still find an inverse U-shaped relationship between test scores for men, and not for women (see Table 7).

6. Conclusion

This study finds that the formation of information links is mostly determined by proximity, consistent with the findings of other studies (Maertens & Barrett, 2013; Mekonnen et al., 2018) and that these determinants differ between men and women. The study also finds evidence of social learning among men (U-shaped relationship between individual test scores and network test scores) among men but not among women. These effects are robust to other
network definitions and the exclusion of high and low performers in the RBPC knowledge test. In addition to this, I find that women reported fewer contacts when answering the questions *advice* and *discuss*, this was also the case for *pass by* and *neighbor*. Women seem to be at a disadvantage both individually and collectively concerning access to information. These findings have implications for the design and implementation of gender-inclusive agricultural interventions. Many studies suggest that providing women with resources such as access to extension services is likely to result in poverty reduction and development (Quisumbing et al., 2014), and therefore inequalities such as the ones found in this study need to be addressed. First, the evidence suggests more training is needed for both men and women in cocoa farming households, and second, extension programs are required to focus on increasing women’s participation and on helping cocoa growers understand the benefits of RBPC. The evidence also suggests that men are more likely to benefit from learning from their information networks and if extension and training programs continue focusing on men this is likely to increase the existing information gaps between men and women.

The use of farmer to farmer dissemination channels has the potential to disseminate RBPC cost-effectively in the context of the Pacific, but more research is required to determine if this is the case and which types of information networks work best for men and women. Additional research on the causal effects of social learning among men and women is required, to confirm the existence of learning effects among men, and to explore what type of networks likely to help disseminate RBPC information among women. This research can lead to benefits that extend beyond the diffusion of information on practices likely to improve the yield and quality of cocoa produced in the Pacific. Gender-inclusive extension strategies based on the use of social networks can help disseminate information about recommended best practices for production, postharvest, and storage of food crops and cash crops, and promote strategies for climate change adaptation.
References


FAO (Ed.). (2018). *Building climate resilience for food security and nutrition*. FAO.


https://doi.org/10.1146/annurev.economics.102308.124433


https://doi.org/10.1016/0047-2727(78)90007-5

https://doi.org/10.1111/agec.12516


Quisumbing, R. Meinzen-Dick, T. L. Raney, A. Croppenstedt, J. A. Behrman, & A. Peterman (Eds.), *Gender in Agriculture: Closing the Knowledge Gap* (pp. 3–27). Springer Netherlands. https://doi.org/10.1007/978-94-017-8616-4_1


https://humanitarianadvisorygroup.org/women-work-men-talk/


Table 1. Individual, household and network characteristics of cocoa growers in Vanuatu, 2018.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Men mean</th>
<th>Men sd</th>
<th>Women mean</th>
<th>Women sd</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age in years</td>
<td>42.80</td>
<td>12.23</td>
<td>40.70</td>
<td>11.50</td>
<td>2.10</td>
</tr>
<tr>
<td>Education in years</td>
<td>4.00</td>
<td>1.62</td>
<td>4.32</td>
<td>1.61</td>
<td>-0.32</td>
</tr>
<tr>
<td>Cocoa farming experience</td>
<td>8.63</td>
<td>8.31</td>
<td>8.22</td>
<td>8.11</td>
<td>0.41</td>
</tr>
<tr>
<td>Health condition = 1</td>
<td>0.46</td>
<td>0.50</td>
<td>0.41</td>
<td>0.49</td>
<td>0.05</td>
</tr>
<tr>
<td>Cocoa related training = 1</td>
<td>0.24</td>
<td>0.43</td>
<td>0.10</td>
<td>0.31</td>
<td>0.13***</td>
</tr>
<tr>
<td>Visited by extension agent = 1</td>
<td>0.48</td>
<td>0.50</td>
<td>0.29</td>
<td>0.46</td>
<td>0.19***</td>
</tr>
<tr>
<td><strong>Participation in community activities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day for the chief (1 to 6)</td>
<td>4.28</td>
<td>1.29</td>
<td>4.05</td>
<td>1.50</td>
<td>0.23</td>
</tr>
<tr>
<td>Day for the church (1 to 6)</td>
<td>4.47</td>
<td>1.07</td>
<td>4.63</td>
<td>0.75</td>
<td>-0.17</td>
</tr>
<tr>
<td>Other community day (1 to 6)</td>
<td>4.39</td>
<td>1.21</td>
<td>4.13</td>
<td>1.53</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Household characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td>4.14</td>
<td>1.61</td>
<td>4.25</td>
<td>1.54</td>
<td>-0.12</td>
</tr>
<tr>
<td>Non-production assets index</td>
<td>-0.01</td>
<td>0.62</td>
<td>0.01</td>
<td>0.62</td>
<td>-0.02</td>
</tr>
<tr>
<td>Production assets index</td>
<td>-0.02</td>
<td>0.50</td>
<td>0.02</td>
<td>0.57</td>
<td>-0.04</td>
</tr>
<tr>
<td>Number of cocoa trees</td>
<td>537</td>
<td>740</td>
<td>550</td>
<td>768</td>
<td>-13</td>
</tr>
<tr>
<td>Time to nearest road in minutes</td>
<td>12.72</td>
<td>17.03</td>
<td>12.41</td>
<td>16.42</td>
<td>0.31</td>
</tr>
<tr>
<td><strong>Number of contacts in cocoa information network</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass by field</td>
<td>4.25</td>
<td>3.08</td>
<td>3.74</td>
<td>2.65</td>
<td>0.51</td>
</tr>
<tr>
<td>Neighbouring field</td>
<td>3.02</td>
<td>2.50</td>
<td>2.26</td>
<td>1.96</td>
<td>0.75***</td>
</tr>
<tr>
<td>Discuss cocoa related issues</td>
<td>4.48</td>
<td>3.56</td>
<td>2.58</td>
<td>3.07</td>
<td>1.91***</td>
</tr>
<tr>
<td>Advice about cocoa</td>
<td>4.29</td>
<td>3.55</td>
<td>2.55</td>
<td>2.98</td>
<td>1.74***</td>
</tr>
<tr>
<td>Belief higher yield</td>
<td>3.72</td>
<td>2.68</td>
<td>2.67</td>
<td>2.37</td>
<td>1.05</td>
</tr>
<tr>
<td>Belief higher quality</td>
<td>2.46</td>
<td>2.68</td>
<td>1.25</td>
<td>2.16</td>
<td>1.20</td>
</tr>
<tr>
<td>Observations</td>
<td>118</td>
<td></td>
<td>106</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a The values of the categorical variables correspond to 1 Never 2 Less than once per month 3 Once a month 4 Once every two weeks 5 Twice per week 6 Once per week.

Levels of significance ***1% **5% *10% for a t-test for equal means.
Table 2. Proportion of men and women participating in cocoa production and postharvest activities, cocoa growing households in Epi Vanuatu, 2018.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Men Mean</th>
<th>Men Std. Dev.</th>
<th>Women Mean</th>
<th>Women Std. Dev.</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weeding</td>
<td>0.73</td>
<td>0.45</td>
<td>0.69</td>
<td>0.47</td>
<td>0.04</td>
</tr>
<tr>
<td>Pruning</td>
<td>0.76</td>
<td>0.43</td>
<td>0.63</td>
<td>0.48</td>
<td>0.13**</td>
</tr>
<tr>
<td>Harvesting</td>
<td>0.64</td>
<td>0.48</td>
<td>0.65</td>
<td>0.48</td>
<td>-0.01</td>
</tr>
<tr>
<td><strong>Postharvest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fermenting</td>
<td>0.40</td>
<td>0.49</td>
<td>0.31</td>
<td>0.47</td>
<td>0.08*</td>
</tr>
<tr>
<td>Drying</td>
<td>0.34</td>
<td>0.48</td>
<td>0.30</td>
<td>0.46</td>
<td>0.04</td>
</tr>
<tr>
<td>Selling wet beans</td>
<td>0.61</td>
<td>0.49</td>
<td>0.57</td>
<td>0.50</td>
<td>0.04</td>
</tr>
<tr>
<td>Selling dry beans</td>
<td>0.39</td>
<td>0.49</td>
<td>0.30</td>
<td>0.46</td>
<td>0.08*</td>
</tr>
</tbody>
</table>

Levels of significance ***1% **5% *10% for a t-test for equal means.
Table 3. Men’s and women’s test scores in the knowledge test. Cocoa growing households Epi Vanuatu, 2018.

<table>
<thead>
<tr>
<th>Test topics</th>
<th>Men</th>
<th>Women</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Dev.</td>
<td>Mean</td>
</tr>
<tr>
<td>Pruning, weeding and harvesting</td>
<td>8.33</td>
<td>3.25</td>
<td>6.92</td>
</tr>
<tr>
<td>Fermenting and drying</td>
<td>4.42</td>
<td>2.70</td>
<td>3.78</td>
</tr>
<tr>
<td>Pest and diseases</td>
<td>2.81</td>
<td>2.07</td>
<td>2.59</td>
</tr>
<tr>
<td>Dry-bean’s problems with pics</td>
<td>2.44</td>
<td>1.62</td>
<td>2.08</td>
</tr>
<tr>
<td>Total test score</td>
<td>18.01</td>
<td>6.28</td>
<td>15.36</td>
</tr>
</tbody>
</table>

Observations 118 106

Levels of significance ***1% **5% *10% for a t-test for equal means.

Marginal effects after probit.

Advice = 1 if Do you go to [name] for advice when you have issues with your cocoa? = 1

Discuss = 1 if Do you discuss any cocoa production or postharvest related issues with [name]? = 1

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Men Advice</th>
<th>Men Discuss</th>
<th>Women Advice</th>
<th>Women Discuss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass by field=1</td>
<td>0.31***</td>
<td>0.34***</td>
<td>0.15***</td>
<td>0.14***</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.04)</td>
<td>(0.04)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Meet frequently</td>
<td>0.07***</td>
<td>0.07***</td>
<td>0.07***</td>
<td>0.07***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Contact's quality higher=1</td>
<td>0.12**</td>
<td>0.12***</td>
<td>0.01</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>d_education</td>
<td>0.02*</td>
<td>0.02**</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>d_household assets</td>
<td>0.06**</td>
<td>0.01</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.02)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>d_number of cocoa trees</td>
<td>0.00</td>
<td>0.00***</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>d_visit from extension agent</td>
<td>-0.02*</td>
<td>-0.01</td>
<td>-0.06*</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>d_participation day for the church</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.03)</td>
<td>(0.04)</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>s_age</td>
<td>0.00*</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>s_education</td>
<td>0.02**</td>
<td>0.02**</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>s_number of cocoa trees</td>
<td>0.00**</td>
<td>0.00***</td>
<td>0.00***</td>
<td>0.00***</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>s_participation day for the church</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.06*</td>
<td>-0.06*</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.03)</td>
<td>(0.04)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Villages variables</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
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<td>1083</td>
<td>974</td>
<td>974</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-523.71</td>
<td>-504.72</td>
<td>-370.93</td>
<td>-384.99</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.3</td>
<td>0.33</td>
<td>0.36</td>
<td>0.34</td>
</tr>
</tbody>
</table>

d means difference and s means sum.

The coefficients for the differences and the sums that are not statistically significant have been omitted.

Clustered standard errors at the individual level in parenthesis.

Levels of significance ***1% **5% *10%
Table 5. Correlates of social learning and knowledge of RBPC. Cocoa growing households Epi Vanuatu, 2018.

Marginal effects after Poisson estimation. Dependent variable: Knowledge test scores.

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Men</th>
<th>Women</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Advice</td>
<td>Discuss</td>
<td>Advice</td>
<td>Discuss</td>
</tr>
<tr>
<td>Avg network score</td>
<td>1.01***</td>
<td>0.90***</td>
<td>0.22</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td>(0.27)</td>
<td>(0.27)</td>
<td>(0.24)</td>
</tr>
<tr>
<td>Avg network score sq</td>
<td>-0.04***</td>
<td>-0.03***</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Age in years</td>
<td>0.24</td>
<td>0.08</td>
<td>0.36</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>(0.23)</td>
<td>(0.22)</td>
<td>(0.34)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>Age sq</td>
<td>-0.00</td>
<td>-0.00</td>
<td>-0.00</td>
<td>-0.00</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Education in years</td>
<td>1.86*</td>
<td>1.68*</td>
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<td>0.32</td>
</tr>
<tr>
<td></td>
<td>(0.96)</td>
<td>(0.89)</td>
<td>(1.25)</td>
<td>(1.39)</td>
</tr>
<tr>
<td>Education sq</td>
<td>-0.22**</td>
<td>-0.20**</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.10)</td>
<td>(0.12)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Cocoa experience</td>
<td>0.37**</td>
<td>0.34**</td>
<td>0.57***</td>
<td>0.57***</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.16)</td>
<td>(0.15)</td>
<td>(0.14)</td>
</tr>
<tr>
<td>Experience sq</td>
<td>-0.01*</td>
<td>-0.01</td>
<td>-0.01***</td>
<td>-0.01***</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Health condition = 1</td>
<td>-1.51</td>
<td>-1.40</td>
<td>-0.33</td>
<td>-0.21</td>
</tr>
<tr>
<td></td>
<td>(0.95)</td>
<td>(0.91)</td>
<td>(1.19)</td>
<td>(1.29)</td>
</tr>
<tr>
<td>Household size</td>
<td>-1.09***</td>
<td>-1.07***</td>
<td>-0.04</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>(0.30)</td>
<td>(0.30)</td>
<td>(0.48)</td>
<td>(0.49)</td>
</tr>
<tr>
<td>Household assets index</td>
<td>-0.31</td>
<td>0.19</td>
<td>0.04</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>(0.97)</td>
<td>(0.93)</td>
<td>(0.82)</td>
<td>(0.80)</td>
</tr>
<tr>
<td>Cocoa productive assets index</td>
<td>1.30**</td>
<td>0.59</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(0.62)</td>
<td>(0.60)</td>
<td>(0.89)</td>
<td>(0.89)</td>
</tr>
<tr>
<td>Number of cocoa trees</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Cocoa related training = 1</td>
<td>0.35</td>
<td>-0.24</td>
<td>0.78</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>(1.29)</td>
<td>(1.23)</td>
<td>(1.47)</td>
<td>(1.45)</td>
</tr>
<tr>
<td>Extension visit =1</td>
<td>-1.67*</td>
<td>-1.45</td>
<td>-2.23*</td>
<td>-2.27*</td>
</tr>
<tr>
<td></td>
<td>(1.02)</td>
<td>(1.01)</td>
<td>(1.28)</td>
<td>(1.28)</td>
</tr>
<tr>
<td>Time to road in minutes</td>
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<td>0.01</td>
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<td>-0.80*</td>
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<td>0.29</td>
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<td>(0.37)</td>
<td>(0.41)</td>
<td>(0.37)</td>
<td>(0.38)</td>
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<tr>
<td>Day for the church (1 to 6)</td>
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<td>0.17</td>
<td>1.54~</td>
<td>1.38~</td>
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<td>(0.42)</td>
<td>(0.46)</td>
<td>(0.94)</td>
<td>(0.95)</td>
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<tr>
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<td>-330.99</td>
<td>-302.73</td>
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</tr>
<tr>
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<td>0.19</td>
<td>0.14</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Observations</td>
<td>118</td>
<td>118</td>
<td>106</td>
<td>106</td>
</tr>
</tbody>
</table>

**The values of the categorical variables correspond to 1 Never 2 Less than once per month 3 Once a month 4 Once every two weeks 5 Twice per week 6 Once per week.

Robust standard errors in parenthesis.
Levels of significance ***1% **5% *10%.

Marginal effects after Poisson estimation.

Dependent variable: Knowledge test scores.

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Excluding 10% HIGHEST test scores</th>
<th>Excluding 10% LOWEST test scores</th>
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</thead>
<tbody>
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<td></td>
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<td>Women</td>
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<tr>
<td>Avg network score</td>
<td>0.58**</td>
<td>0.81***</td>
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<tr>
<td>Avg network score sq</td>
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<td>-0.03**</td>
</tr>
<tr>
<td></td>
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<td>(0.01)</td>
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<td>Individual Characteristics</td>
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<td>YES</td>
</tr>
<tr>
<td>Network Characteristics</td>
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<td>YES</td>
</tr>
<tr>
<td>Village variables</td>
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<td>YES</td>
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<tr>
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<td>-286.34</td>
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<tr>
<td>Pseudo R2</td>
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<td>0.14</td>
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<tr>
<td>Observations</td>
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</table>

Robust standard errors in parenthesis.

Levels of significance ***1% **5% *10%

Marginal effects after Poisson estimation.

Dependent variable: Knowledge test scores.

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pass by</td>
<td>neighbour</td>
</tr>
<tr>
<td>Avg network score</td>
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<td>0.69***</td>
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<tr>
<td>Avg network score sq</td>
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<td>-0.03***</td>
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<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Individual Characteristics</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Network Characteristics</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Village variables</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>Log likelihood</td>
<td>-334.15</td>
<td>-336.51</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.19</td>
<td>0.18</td>
</tr>
<tr>
<td>Observations</td>
<td>118</td>
<td>118</td>
</tr>
</tbody>
</table>

Robust standard errors in parenthesis.

Levels of significance ***1% **5% *10%
Figure 1. Kernel distribution of Men’s and Women’s RBPC knowledge test scores.
Vanuatu, 2018.

Correct answers in bold.

**Pruning**

1. What are the benefits of cutting chupons/water shoots? (multiple answer)
   - a. Avoids excess branches (young trees)
   - b. Reserve nutrients (established trees)
   - c. Improve light penetration and airflow (established trees)
   - d. None of the above
   - e. DK

2. What are the benefits of cutting diseased branches off a tree and low hanging branches? (multiple answer)
   - a. Increase sunlight
   - b. Increase airflow
   - c. Prevent and reduce pest and disease problems
   - d. Prevent and reduce weeds problems
   - e. Promote pod development
   - f. None of the above
   - g. DK

3. If you want to stimulate the yield of your cocoa trees for the next season, what should you do? (multiple answers)
   - a. Pruning of cocoa trees after each harvest season
   - b. Apply manure to the cocoa trees after harvesting
   - c. Use pruned healthy branches from trees for mulching/compost.
   - d. None of the above
   - e. DK

**Weeding**

4. What are the advantages of removing weeds from under the cocoa trees? (multiple answer)
   - a. Reduce pests and diseases
   - b. Increase water and nutrient availability
   - c. Improve access to trees
   - d. None of the above
   - e. DK

5. What do you do to prevent pests and diseases in your cocoa plot? (multiple answer)
   - a. Pruning
   - b. Weeding/cleaning under the cocoa tree
   - c. Harvest pods weekly during the rainy season
   - d. Harvest pods weekly during the dry season
e. Apply chemical pesticides/herbicides
f. None of the above
g. DK

Harvesting

6. How often should you harvest ripe cocoa pods?
Correct answer: every 1, 2 to 3 weeks depending on the number of ripe pods.
(single answer)
   a. Every week
   b. Every two weeks
   c. Every three weeks
   d. Less than once a week
e. More than three weeks
f. DK

7. How long should you wait before you open the pods after harvesting?
Correct answer: No more than one week after harvesting.
(single answer)
   a. No more than one week after harvesting
   b. More than one week after harvesting
c. DK

Fermenting

8. When fermenting in wooden boxes, these boxes should be filled
(single answer)
   a. Completely filled (all the way to the top of the box)
   b. 60% filled
c. Any amount
d. Other
e. DK

9. How long should you wait to ferment beans after they are removed from the pods?
(single answer)
   a. 24 hours (one day) or less
   b. More than 24 hours (more than 1 day)
c. DK

10. How will you cover the fermented beans while fermenting?
(single answer)
    a. Banana leaves and clean sacks
    b. Plastic
c. Do not cover
d. Other
e. DK

11. When fermenting cocoa beans, how often should you turn them?
(single answer)
    a. Once a day
b. Every two days (every other day)
c. Every three days
d. No need to turn them
e. DK

12. For how many days should you ferment wet cocoa beans?
(single answer, there are two potential right answers)
   a. 5 days or less
   b. between 6 and 8 days depending on the whether
   c. more than 8 days
   d. DK

Drying

13. What is the best way to dry cocoa beans?
(single answer)
   a. Hot air
   b. Sun dry
   c. Hot air and sun dry
   d. DK

14. When drying using a sun dryer, how often should you turn beans in the dryer?
(single answer)
   a. Every hour
   b. Less than every hour
   c. More than every hour
   d. DK

15. When sun drying, how long should you dry cocoa beans?
(single answer)
   a. 1 day/24 hours
   a. 2 days/48 hours
   b. 3 days
   c. Between 4 and 7 days depending on the whether
   d. More than 7 days
   e. DK

16. Why some cocoa beans are flat after drying?
(single answer)
   a. The beans were harvested too early
   b. They haven’t been fermented correctly
   c. Other
   d. DK

Pests and diseases

17. What is the best way to reduce the impact of rats?
(multiple answer)
   a. Place rat poison in cocoa plot
b. Introduce cats and snakes to eat them
c. Provide alternate food for them, such as half coconut in trees
d. Cleaning/weeding around trees
e. Regularly harvest pods before rats eat them
f. Try and destroy rat breeding sites in cocoa plot
g. Other
h. DK

18. How is black pod spread? (multiple answer)
   a. Rain/water
   b. From the soil
   c. Rats
   d. Insects
   e. Not enough light/too much shade
   f. Other
   g. DK

19. What is the best way to reduce the number of black pods? (multiple answer)
   a. Pruning
   b. Spraying chemicals
   c. Removing black pods from trees
d. Cleaning/weeding under the cocoa trees
e. None of the above
   f. DK

Show the picture on the next page to the respondent and ask the following questions:

20. Do you think the beans in this picture are good quality beans? 
   a. Yes
   b. No
   c. DK

If Yes ask the following question, if the answer is No, go to the next module of the questionnaire.

21. Ask the respondent to identify the beans that are not of good quality and the particular problems with the different beans shown in the picture, enter the number that identifies the bean in the picture for each of the problems mentioned. Multiple answers allowed:
   a. Unfermented 3, 4, 5
   b. Mouldy 8, 9
   c. Germinated 6
   d. Harvested to early 2
   e. Bad beans 2 to 9
22. Dry cocoa beans picture used in question 21.

Picture by Ben Kolly.
Supplementary material

A2. Assets and PCA loadings

A3. Full Regression Tables (4 to 7)

A4. Regression Tables using OLS (4 and 5)