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# Love Thy Neighbour?

## Evidence from Ethnic Discrimination in Information Sharing within Villages

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**Abstract**

There is increasing evidence to suggest that a fundamental source of information for farmers on how to access and use new agricultural technologies comes from interacting with neighbours. Economic research on adoption of innovations in a rural context has only partially addressed the issue of how the social structure of a village can affect adoption and the final impact on productivity of farmers. This paper investigates the role of proximity interpreted not only in geographical terms but also along the line of ethnic similarities among neighbours (what we define as 'social proximity'). We use a panel dataset collected in Côte d'Ivoire to define the probability of accessing the knowledge network. The main results indicate that farmers from ethnic minorities are less likely to access, and benefit less from, extension services. But they seem to try to re-equalize their condition by putting more effort than dominant ethnic group neighbours in sharing information among themselves.

Keywords: economic development, technological change, growth

JEL classification: O1, O3, Q1



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# 1 Introduction

There is increasing evidence to suggest that a fundamental source of information on how to access and use new technologies in a rural production context comes from interaction with neighbouring farmers[1]. Economic research on adoption of innovations has only partially addressed the issue of how the social structure of a village can affect the exchange of information, the adoption and the final impact of the innovation to farmers' productivity (Feder and Slade 1984; Bevan et al 1989; Pomp and Burger 1995; Foster and Rosenzweig 1995, Conley and Udry 2002).

Previous work on Côte d'Ivoire reveals a negative bias against non-autochthonous farmers in accessing institutional knowledge, in the form of extension services. This finding relates to the "ethnic sequence" in the history of integration of non-indigenous communities in cocoa growing areas of the country; the recent crisis in the cocoa and coffee market combined with the recent political instability deeply changed this precarious equilibrium (see Leonard and Oswald, in Ruf, F. and Siswoputranto, P.S. (eds) 1995). This paper investigates the extent to which information flows within and between different ethnic groups in the village. The key idea is that culturally more homogeneous farmers will interact more, and therefore share more information about technological innovations. In this context it was shown that minorities create strong and efficient networks to safeguard their diversity (Feder and O'Mara 1982, Fafchamps 2000, Ruf, 1995). Most previous work in this field is limited by lack of access to panel data and by identification problems resulting from the definition of networks[2]. This paper attempts to avoid these identification problems through two devices: first by not using the traditional average effect approach to networks, but rather trying to develop a variable to express the probability of

[1] For a seminal paper in this field see Case (1992)

[2] For a detailed discussion of identification problems in network analysis see Manski (1993) and and Ravallion (2002).

each farmer to access knowledge through his/her participation in the network and his/her ethnic characteristics; second by using a short panel dataset.

Section 2 will investigate the relationship between social structure and formation of networks, while section 3 will describe the simple model used to test the theory. Section 4 will describe the data available to test the hypothesis and section 5 will introduce some preliminary results on the ethnic component. Section 6 will set up the empirical formulation, Section 7 will illustrate the main results and section 8 will conclude.

## 2 Technology adoption and social structure

Being a member of a community gives a farmer the advantage of sharing information on production techniques and innovations: this simple but sensible idea has produced interesting theoretical developments that have led to important empirical findings. In the last 20 years, evidence suggested that the way in which societies are organized and social groups interact can have an impact on the diffusion of knowledge and its consequent impact on the productivity of crops (Banerjee, 1992; Case, 1992; Besley and Case, 1994; Foster and Rosenzweig 1995, Conley and Udry, 2001). While these studies provided an invaluable theoretical platform to better understand the role of networks, there is still a lack of clarity on the role of social structures in determining the amount and the quality of the exchange of information among neighbours. This aspect remains difficult to model, as it is deeply rooted into the social characteristics of the environment where the empirical analysis is carried out. It is important and often difficult to distinguish between the effect deriving from the characteristics of the individual and the social capital effect, which concerns the entire community attitude towards sharing knowledge. Rogers (1995) uses well-established theories in sociology, psychology, and communications to develop a concise approach to the diffusion of innovations: diffusion takes place within the context of structures of social relationships based on power, norms and public acceptability. Communication networks (who you know), structure (what is your place in the chain of communication) and proximity (degree of overlapping personal communication between members) are all key elements in predicting adoption and, ultimately, the impact on productivity of farmers. While the literature on empirical testing of these theories is rather limited, some interesting results have emerged in the context of ethnic homogeneity and efficiency (Kanbur 1992; Baland and Plateau 1995; Fafchamps 2000). In the more specific context of peer effects and ethnic homogeneity recent papers by Munshi and Myaux (1998) and Munshi (2002) find evidence that similar ethnic origins and religious affiliations have a role in explaining the adoption of innovation in the context of sanitation and agricultural production respectively.

As previously noticed, it is difficult to understand the role of social structures without considering the specific social context. Prior to proposing a model we therefore need to understand the setting. Previous work on Côte d'Ivoire has focused on the positive impact of extension services on the productivity of farmers, mainly as far as food crops are concerned (Romani 2002). The central idea is that the farmer who receives extension, and has invested in the acquisition of information about the innovation, may in the course of this process communicate with neighbours, maybe to receive help with the application of the innovation, or additional advice. The main result of that analysis is a positive effect of extension services on food crops, but not on the more valuable perennial crops (coffee and, most importantly, cocoa). This is the result of the crisis in the international prices of these soft commodities over the last few years. Old plantations were not maintained properly or replaced by new ones, causing a decrease in yield levels. Extension became increasingly unable to sustain the cocoa sector in particular, in a context where farmers were turning their effort to food crops to provide for their households. Farmers turned to crops like maize and cassava as they can be grown on short term fallows and require little work.

Lowlands were also exploited with flooded rice, which became increasingly important. The use of inputs in the cocoa production almost stopped: especially anti-parasites equipment was not maintained and became unusable. An interesting case study from a village in the Gban region in central Côte d'Ivoire reveals that once the farmers realized that the price crisis was there to stay and was not temporary as some of the previous ones, they stopped any maintenance of cocoa plots, sometimes leaving abandoned as much as 5 ha of land (Chavueau in Ruf, F. and Siswoputranto, P.S. (eds) 1995). This profound change in the economic structure of the village went along with a reorganization of the ethnic hierarchy: this change exacerbated social tensions in a delicate and complex political moment, in which ethnic differences played a critical role. While it is difficult to generalize, three farmers groups can be identified: indigenous farmers, first stage immigrants and second stage immigrants. Indigenous farmers are - historically - the wealthiest group; they own the best land and are experienced cocoa and coffee growers. First stage immigrants are established households who moved to the cocoa and coffee growing regions from other areas of Côte d'Ivoire mainly in the 1970s and 1980s. They usually own some land and, despite the fact that they first moved to supply labour to the wealthy indigenous farmers, they are reputed to be experienced and dynamic cocoa and coffee growers. Second stage immigrants have recently arrived to cocoa and coffee growing regions to be employed as workforce. They may have established themselves as small growers, but only rarely own the land they cultivate. Traditionally the hierarchy between the groups depends crucially on the quantity and quality of their perennial crops holdings, which is why the recent crisis has deeply changed the balance of power within the communities.

We propose a simple model to integrate these aspects by focusing on two characteristics of the diffusion of knowledge. In the first place the greater the opportunity of meeting and discussing among farmers the higher is the probability for the farmer to exchange information with "knowledgeable" neighbours and replicate the innovation. We can define this dimension through the presence of participatory organizations in the village as a tool to construct effective networks among the nearby farmers and increase the probability of exchange[3]. Secondly the extent to which innovative farmers will be willing to share such information may vary according to farmers' characteristics. We argue, in line with the literature reviewed earlier, that the greater the similarity in terms of backgrounds, customs and language among the farmers, the higher is the probability the information will be passed on - what is known as the peer-group effect (Pomp and Bruger 1995). Recent models of proximity prefer a more complex concept of distance to a merely geographical definition; this is defined over different spheres of household characteristics, geographical and not (Conley and Ligon 1998), more on the lines of a "social proximity". Ethnic characteristics are a suitable dimension to define the likelihood of interaction among households, particularly, as we said, in the context of the crisis. Since the beginning of the 1990s ethnic affiliations have determined various patterns of land accumulation and production choices.

While similar research was conducted in some recent literature, often the results were based on cross sectional data. As noticed in Ravallion (2002) testing for externalities among units located in the same geographical areas with cross sectional data poses critical identification problems: individual outcomes and geographical variables are likely to be correlated. This is an endogenous effect due to the households' unobservable characteristics, and therefore origin of non-causal correlations: "better" farmers might decide to live in a specific area to enhance their production levels (say because of an unobserved characteristic, such as land quality). Their neighbourhood variable would then seem to determine efficiency, while it is simply proxing for their skillful choice to live in higher potential areas. The availability of a panel dataset allows us to use a fixed effect model that

[3] By Participatory organizations we mean organizations that bring together village members to discuss common problems and determine possible solutions.

increases significantly the capability to identify externalities and network effects among households "cleaned" of possible spurious effects which would invalidate the precision of the result. Fixed effects techniques, through first differencing, allow static unobservable differences (such as land quality and farmer's abilities - at least in the short run) to be controlled for by looking at how variations in efficiency are determined by variations of farmers and environment characteristics (such as membership in networks in our case). Although these techniques have represented a leap forward in the empirical literature, they are not a panacea. If there is an unobservable *dynamic* effect, i.e. we believe that it may influence the ability to *change* rather than (only) the levels of efficiency, then fixed effects techniques will not be sufficient to guarantee identification. Manski (1993) discusses what information is necessary to identify whether the average behaviour of a certain reference group influences the behaviour of the individuals that comprise the group. Inference is not possible unless some prior information specifying the composition of the group is available, and the relationship between the variables defining reference groups and those directly affecting outcomes are moderately related in the population. This condition, that derives from what is known as the reflection problem, is one of the main hurdles to clear results in the existing literature. The aim of this paper is to combine a model that takes into account explicitly the composition of the networks with fixed effect estimation techniques that try to address the identification problems highlighted by this critique of the existing literature.

## 3 The model

The starting platform used in this analysis is the Feder and Slade model of technology adoption in the context of agricultural production (Feder and Slade 1984). We expand it to include knowledge similarly to what is proposed in Isham (forthcoming): a production function that, besides the usual inputs, is increasing in knowledge

$$Y_i = F(L_i, g(K_i), N_i) \tag{1}$$

where $Y_i$ is the total production for farmer i, $K_i$ is his/her knowledge about the innovation, $L_i$ is land and $N_i$ is the positive amount of the variable input used by farmer $i$ that is likely to be affected by the introduced innovation. The general impact of knowledge originates from $g(.)$ which is a concave function. As $K$ increases, $g(.)$ converges to an upper limit $g^*$ as the farmer's cumulative knowledge increases to its maximum . Farmers who do not receive extension are limited to $K_0$ and, consequently, to $g_0^*$ while farmers that receive extension can accumulate knowledge up to $K_1$ and reach $g_1^* > g_0^*$. We expand this model introducing the concept of probability of accessing knowledge. For the moment, we restrict the knowledge to be categorical: either people know how to use the input optimally ($K = 1$) or they don't ($K = 0$), so that $g$ can only assume values $g_0^*$ or $g_1^*$ (we will relax this assumption at a later stage). The knowledge, by allowing $g$ to take the top value $g_1^*$ will have the potential to boost the overall output $Y$. The probability of accessing the information for a farmer who is involved in extension is, by definition, unity. The probability for a farmer who is not in extension "to know" must be lower than 1.

Let us consider a social context where there are $N = 1, ..i..., n$ individuals who are not members of extension and $M = 1, ..j.., m$ individuals in extension. Each "social context" will be one village, so that individuals $i$ and individuals $j$ will be neighbours. At each moment $t$ an event occurs: the event is either an interaction between two members of the two different groups or nothing. We can define $\theta$ as the distribution generating function of these events. An interaction between $i$ and $j$ happens with probability $\theta_{ij}$. If $\theta_{ij} > 0$ then $i$ and $j$ become partners and the information is exchanged.[4] We are interested in defining

[4] The model used here is a slightly modified version of a model analysed in Raub and Weesie (1990).

such a probability function. In words: what makes $i$ more or less likely to interact and exchange information with a member of $M$? We believe this probability to depend on two parameters: the number of "knowledgeable" farmers linked directly to the farmer $i$ , $(B_i)$, and the fact that these farmers might be more or less willing to share the information, $(v_j)$:

$$\theta_{ij} = \theta(B_i, v_j) \tag{2}$$

So $\theta_{ij}$, at this point, can be simply introduced into our farmer's production function, which will be:

$$Y_i = F(L_i, \theta_{ij}, N_i) \tag{3}$$

Notice that $\theta_{ij}$ now represents the probability of accessing our $K = 1$ and therefore to reach $g_1^*$: in other words, in this simplified model, the probability might change but the *quality* of the information is the same for all. This could be, for example, a set instructions to use a new seed: either the farmer knows how to use it or he/she does not know.

Let us now relax the assumption that knowledge is discrete, and allow for its accumulation. Concretely we can think about a more diversified extension system that provides information about several crops and techniques, which increases with exposure to the agent and varies from farmer to farmer. This will not change our definition of probability of knowing, but will add a new variable in our already augmented production function, which is the knowledge function we defined before:

$$Y_i = F(L_i, \theta_{ij}, g(K_i), N_i) \tag{4}$$

Where now $K$ is a stock variable, free to take any positive value. The magnitude of

$K$ will depend on the overall stock of knowledge available in the network of farmer $i$. Overall productivity is increasing in $\theta_{ij}$ (the probability of knowing) and in knowledge $g(K_i)$. Notice how now the impact of knowledge on total output will be conditional to $\theta_{ij}$, the probability of accessing such knowledge. We can define $\theta * K$ as the value of expected knowledge available to farmers.

## 4 The data

The data comes from a panel data survey managed by ANADER on a sample of 2500 households evenly spread across the territory. The survey was collected between 1997 and 2000, and contains information about production during the ending farming season (so data collected in 1999 pertain to the 1998-1999 farming season). This survey is collected among a sub-sample of a bigger survey (comprising more than 10000 households), with additional information about the households, collected only once in 1997. This data was also available for the analysis. The panel data survey focused on farmer's production capabilities, with precise information about single plots and crops for each household. Both the panel sub-sample and the bigger cross sectional sample include information about the ethnic origin of the household and on the membership in both extension services (only available for the sub-sample) and in participatory organizations (available for both the panel and the cross sectional sample)[5]. Table 1 summarizes the trends in average production per household, average total land surface per household, average crop density, and yields for of some of the crops object of the analysis during the period 1998-2000.[6]

The yield levels for cocoa seem to have deteriorated considerably from 1998 to 2000. Quite interestingly the average size of the cocoa cultivated areas tend to decrease sub-

[5] There are different kind of cooperatives recorded in the survey: production groups, marketing groups, production cooperatives, trade unions and other groups. Given that in each village, though, only 1 organization is present, we aggregate them in to one category.

[6] For further information about the survey structure and the sampling procedures see Appendix 1.

stantially, especially from 1999 to 2000. This result is consistent with the more accurate analysis possible through panel data: in fact following the households from period to period we come to a similar conclusion. With the exception of a few farmers who increased cocoa cultivated areas extensively, on average there was a contraction in the size of cocoa cultivated areas. No information was provided in the survey as to whether the farmers actually removed cocoa trees or simply did not use their full potential of cultivation, perhaps not using the older trees. The anthropological survey carried out by J.P. Chavueau in the Gban region in central Côte d'Ivoire, offers an interesting insight over the new cultural arrangements over the greater competition for limited resources resulting from the slump in the cocoa cycle. Often farmers decided not to maintain old plantations, to give space for new forest growth and terrain renewal as, in their judgement, the cost of forgoing cocoa production in a period of depressed prices is lower than the present value of the profit of expected future production. Facing unaffordable prices for inputs such as pesticides and fertilizers, farmers extended the size of their plantations, without maintaining them accurately, given the very low marginal cost of expanding the cultivated surface (Chavueau in Ruf, F. and Siswoputranto, P.S. (eds) 1995). Generally, whatever the solution adopted by the farmers, the result is a contraction of the average cocoa operation confirmed by the decrease in average output per household. Similar conclusions, regarding the size of the plots, can be drawn from the analysis of the coffee data. The reduction in output is also drastic: this could be due to a reduction in the effort and land dedicated to coffee cultivation and harvesting during a period of low prices and consequent low profitability. The case study mentioned above helps us understand some of the factors connected to the labour input as well. Bigger farms adapted quickly to the new constraints, reducing drastically the daily labour hired for the maintenance of the plots. Smaller farmers, given the lack of secondary inputs, had to increasingly rely on labour to maintain production levels as far as it was possible (and convenient) to substitute these two factors.[7] This was done almost exclusively by using family labour, as they could not afford hired labour. Eventually, as the profitability of the cocoa plantations kept decreasing, farmers started moving their effort (and their family labour force) away from perennials to focus on food crops.

Table 2 summarizes the information about ethnic origin by region. The distinction is between indigenous farmers, non indigenous farmers (which are farmers belonging to different kin but of Ivorian citizenship) and foreign farmers. The regions where cocoa and coffee are grown experienced significant immigration in the past, particularly during the boom years in the cocoa markets of the 80s and early 90s. Despite the innovations in the production techniques, the high level of cocoa production in the country from 1988 onwards can be attributed to the new migrations associated with deforestation and creation of new plantations. This is particularly true for the south-west cocoa growing region, which developed only after the opening of the road from Abidjan to Sassandra[8]. All these areas held the largest reserves of primary forest in the country. The government limited the customary rights of native people and practically gave away the forests as free concessions to the newcomers. The opening up of these forest lands induced a huge influx of immigrant labour, coming mostly from the north of the country and from neighbouring Mali and Burkina Faso (these are the farmers classified as non-autochthonous in the survey). The government, following the slogan "the land belongs to those who develop it" assured the transfer of land to farmers who would show the ability to quickly develop their small holdings. This mechanism of exchanging land for labour fuelled a sort of "gold rush" to the forest, accompanied by a mushrooming of frontier settlements. Land settlement and deforestation continued in a inevitable self-feeding mechanism in which the strongly

[7] Ruf (1995).

[8] For a comprehensive description of the migration flows in Côte d'Ivoire, see Ruf (1993), chapter 3, p. 199-221.

needed extra labour could be attracted only by providing the newcomers with land to settle on. Older settlements, owned by indigenous farmers, found it increasingly difficult to compete the new frontier areas where newer trees and abundant cheap workforce were available.

Yam and cocoa inter-planting methods were widely adopted by the newcomers. Cocoa is planted in April/May, then plantain and cassava are added to the fields. The marginal cost of growing cocoa in this setting is close to nothing, thanks to the almost perfect complementarities among these plants. The food crops remunerate, during the first year, the investment in the plot. After the yam is harvested, the cocoa provides for weed control, reducing maintenance work required. Density of the cocoa trees is then reduced until production period. The sustainability of this widespread system is not very good, and after some years of exploitation it reaches its "ecological ceiling". Bad timing made this stage correspond, for many of the settlements, with the decrease in international prices. This was another factor that caused farmers to increase their food crop cultivations, especially in the form of shade-food crops, which grow underneath the cocoa trees (Chavueau in Ruf, F. and Siswoputranto, P.S. (eds) 1995).

## 5 The role of ethnic diversity

The probability of accessing knowledge which was defined in section 3 is the key element in our model. We seek a definition for the two main determinants of the probability which we described earlier on: the number of "knowledgeable" farmers that the "non-knowledgeable" farmer $i$ knows ($B$) and the fact that these farmers might be more or less willing to share the information with our farmer ($v$). We use information about membership in cooperatives to define the network of each farmer. We assume, by this, that farmers who belong to cooperatives have a significantly higher chance of meeting among themselves in a context in which they are likely to discuss production issues[9]. This is justified by the fact that cooperatives are sociable places, where the farmer goes regularly to sell his goods, to purchase inputs or simply to check the most recent prices before heading for the nearby market. Cooperatives, normally, do not offer production advice, but mainly marketing services or - in some cases - the sale of inputs. According to local experts, membership in cooperatives does not imply anymore better access to inputs, as was the case previously. In fact these institutions, during the crisis period, lacked the cashflow needed to make big purchases of inputs. Still they seem to play an important role as information centres where farmers meet to discuss production issues.

Once we have characterized the network-participation of farmers by their membership in a cooperative, we can calculate the probability of meeting a neighbour in extension ($B$): it will be equal to the number of cooperative members who are also extension members over the total number of cooperative members in the community. To define the second determinant we start from the fact that ethnic diversity seems to play an important role in determining membership in extension. Table 3 and 3.1 report some descriptive statistics on access to extension and the results of a probit estimation on the factors that make a household more or less likely to be a member of an extension group.

We include a number of households characteristics on the right hand side, of which we report only the most important ones. Interestingly the results indicate that belonging to the non autochthonous ethnic group reduces significantly the probability of being a member of extension services, even after controlling for other household characteristics. This result should be interpreted more as a descriptive statistic rather than as causal effect as this very simple cross sectional estimation is undermined by some identification

[9] The dataset contains information about membership in several types of cooperatives, which we generalized in one category. This will not cause probalmes, as far as networks are concerned, as in each community there is rarely more than one cooperative. The heterogeneity of cooperative types - in other words, is intervillage and not intrevillage.

problems. Most importantly it is difficult to rule out the possibility of selection bias into extension services. It maybe the case that good farmers seek extension or that extension is particularly designed to help farmers who cultivate specific crops. The nature of the extension scheme in Côte d'Ivoire, though, helps to address this issue: agents are located homogeneously on the territory and provide information on all crops, not only on perennials[10]. We can take this result one step further and look at whether ethnic origin has an overall effect on the characteristics of the farming activity, i.e. whether - once they receive extension - they benefit from it as much as households belonging to the dominant ethnic group. Table 4 reports the results from a production function fixed effect panel regression for the entire sample during the period 1998-2000. The results are similar to the ones reported in Romani (2002), but the effect of extension is now interacted with the ethnic origin of the farmers and the type of crop (food crops and perennials). The coefficients on the interaction variables tell us, therefore, what is the impact of extension services on food crops and commercial crops for the two ethnic categories separately. Interestingly the positive effect on food crops, which was the main result found in that study, seems to be common for both autochthonous and non autochthonous farmers, but with only a significant difference in the magnitude of the impact[11]. This indicates that in the (relatively unlikely) case in which the ethnic non-autochthonous farmers do receive extension, they are able to benefit from it a little less than the households belonging to dominant ethnic groups. Are non-indigenous farmers more or less effective in farming? We cannot answer this question looking at our fixed effect regression, given that the ethnic origin is part of the unobservable characteristics "swept out" by our fixed effects estimates. We therefore look at the production function derived from the cross sectional survey collected on the same farmers in 1997. We run a production function including

[10] For a more detailed discussion of this issue see Romani (2002).

[11] The positive effect of extension is in line with the literature (for a review of studies on the impact of extension services see Evanson, forthcoming).

a number of characteristics of the households to compensate for the lack of control for unobservable differences, given that now we are not using a fixed effect technique. Results are reported in table 5; they indicate that the ethnic minorities are not disadvantaged in food crops production and, on the contrary, seem to be advantaged as far as perennial crops are concerned, even after controlling for the age of the plants. This is an important factor, given that most foreign and non autochthonous farmers moved to cocoa growing areas during the cocoa boom in the 80s and, therefore, tend to have younger and more productive trees. Indeed the age of the trees, and perhaps the adoption of different perennial/annual crop combinations are at the basis of the different effects of cocoa-cycles on indigenous and non-indigenous farmers (Ruf, 1995).

In this section we identified two main facts:

1. Foreign and non-indigenous farmers are less likely to be involved in extension services and therefore to become members of extension groups

2. Once they are members of extension they benefit from it less than the dominant ethnic group members.

It is clear that the ethnic origin of the farmers plays a role in determining whether and in what ways the information that arrives into the village through extension effects productivity. We therefore will model our parameter $v$, the willingness to share information, along ethnic lines. This will allow us to construct probabilities which vary according to the ethnic origin of the farmer and the ethnic specific share of knowledgeable farmers he/she can meet through cooperatives. The key idea is that farmers tend to interact more within their own ethnic group, even if they belong to a mixed common network, such as a cooperative.

With $v$ and $B$ we now have the two elements to define the overall probability "of knowing a neighbour who knows" in each village. This little table summarizes the probability for each group:

| *Probability of "knowing a neighbour who knows"* | | Membership in extension | |
|---|---|---|---|
| | | *yes* | *no* |
| Membership in the cooperative | *yes* | $Pr[K=1]=1$ | $0 \leq Pr[K=1] \leq 1$ |
| network | *no* | $Pr[K=1]=1$ | $Pr[K=1]=0$ |

The case in which $0 \leq Pr[K=1] \leq 1$ (not a member of extension but a member of the cooperative network), the probability is equal to:

$$\theta_i = \frac{\text{\# of village members who belong to the cooperative and to extension}}{\text{tot \# of village members who belong to the cooperative}} \quad (5)$$

which is the probability of "knowing a neighbour who knows" as this is defined for each village[12]. Including the ethnical component the probability becomes :

$$\tilde{\theta}_i = \frac{\text{\# of village members who belong to the cooperative, to extension and of i's ethnic group}}{\text{tot \# of village members who belong to the cooperative of i's ethnic group}} \quad (6)$$

which is the probability "of knowing a neighbour who knows of my ethnic group".

Next we relax the assumption of $K$ taking only values 0 and 1, and we consider $K$ being an accumulable stock of knowledge ($K \geq 0$). We want $K$ to increase with the overall amount of knowledge present in i's village. We define, therefore, $K$ as the number of members of the extension group present in i's community. We then derive the values for the "expected knowledge" very simply in the following manner:

$$\theta_i * K = \frac{\text{\# of village members who belong to the cooperative and to extension}}{\text{tot \# of village members who belong to the cooperative}} * K \quad (7)$$

[12] We consider people who live in the same village as neighbours as we do not have access to information on distances among them. The relatively small size of villages makes this assumption not too irrealistic.

for the non-ethnic specific network effect. The ethnic specific expected knowledge is derived similarly:

$$\tilde{\theta}_i * K = \frac{\text{\# of village members who belong to the cooperative, to extension and of i's ethnic group}}{\text{tot \# of village members who belong to the cooperative of i's ethnic group}} * K. \tag{8}$$

Notice that these variables, by construction, will take values between 0 and $K$.

## 6 The Empirical Formulation

The main hypothesis deriving from the simple theoretical model is that information moves more fluidly between neighbours with a higher social proximity (in terms of our model with a higher $v$, i.e. the amount of information farmers share in the network). In other words we expect the $g^*|\theta$ (that is the upper limit of the impact of information on production, given a certain probability of accessing knowledge) to be higher among "homogeneous" ethnic groups. We will arrive to this test gradually.

We start from a standard multi crop production function, augmented with an extension membership dummy ($ext_{it}$):

$$y_{it} = A(z) l_{it}^{a_l} n_{it}^{a_n} e^{a_{ext} ext_{it}} \tag{9}$$

where $l_{it}$ represents fixed inputs and $n_{it}$ variable inputs. Cultivated land constitutes the fixed input, and it is crop specific. Only limited information is available on variable inputs, in particular for labour for which the only information we can use is the number of working age members in the household over the number of plots belonging to the household. While it would be preferable to have more precise information such as hours worked, in the context of the crisis hired labour is a form of input that only few larger farms can afford. Indeed, as noticed in Ruf and Siswoputranto (1995), bigger families were advantaged during the crisis period when due to the lack of other inputs more intense labour was the only response: "Such a strategy is only possible when farmers have a sizable family work force (...) this explains why the strategy is mostly adopted by planters who migrated from Burkina Faso and Mali. These ethnic groups can rely on their family or village networks to provide them with a stable but not too demanding labour force."[13] The number of household members per plot seems also to fit well the labour patterns observed in the country, where each one or two household members (according to the overall size of the family) are allocated specific plots that they are responsible for (Udry and Duflo, 2001). We propose to first test for our simpler model (equation 3), in which knowledge $K$ takes only values 0 or 1 (the case in which we hypothesized - to clarify the model - that the innovation consisted in a new seed):

$$y_{it} = A(z) l_{it}^{a_l} n_{it}^{a_n} e^{a_{ext} ext_{it}} e^{a_\theta \theta_{it}} \tag{10}$$

where $\theta_{it}$ is the probability "of knowing a neighbour who knows" as defined in (5). We assume that the probability enters our relationship exponentially similarly to extension. Linearizing and adding the error term and the fixed effects we obtain:

$$\log y_{it} = \log A(z) + a_l \log l_{it} + a_n \log n_{it} + a_{ext} ext_{it} + a_\theta \theta_{it} + \varepsilon_{it} + \omega_i \tag{11}$$

This equation will therefore test whether the probability of knowing somebody who has access to extension, whatever his or her ethnic group, is associated with higher output levels controlling for other determinants of production. This can be interpreted as a test of the amount of knowledge sharing among network members.

[13] See Ruf and Siswoputranto, 1995 (p.138). While more precise information on labour, such as hours worked, would be preferable, it could introduce some simultaneity between the regressor and the error term. If in fact unobservable shocks were to be correlated with the labour variable the coefficient of the regressor would be biased. Using an exogenous measure such as number of household members over number of plots to proxy for labour solves this problem.

Secondly we introduce the ethnic element. Now we will be testing whether the probability of knowing somebody who knows and is a member of the same ethnic group is associated with higher output levels.

$$y_{it} = A(z) l_{it}^{a_l} n_{it}^{a_n} e^{a_{ext} ext_{it}} e^{a_K (\widetilde{\theta}_{it})} \tag{12}$$

Log-linearizing and adding the error term and the fixed effects we obtain the following linear specification:

$$\log y_{it} = \log A(z) + a_l \log l_{it} + a_n \log n_{it} + a_{ext} ext_{it} + a_\theta \widetilde{\theta}_{it} + \varepsilon_{it} + \omega_i \tag{13}$$

where $\widetilde{\theta}_{it}$ is the ethnic specific probability defined in (6). This equation tests whether there is an intra ethnic exchange of information.

We proceed similarly to construct the empirical formulations for the "expected knowledge" model, using the definitions given in (7) and (8) where K is the number of extension members in each community. First without the ethnic element in the definition of the networks:

$$\log y_{it} = \log A(z) + a_l \log l_{it} + a_n \log n_{it} + a_{ext} ext_{it} + a_\theta (\theta_{it} * K) + \varepsilon_{it} + \omega_i \tag{14}$$

and with the ethnic-specific probability:

$$\log y_{it} = \log A(z) + a_l \log l_{it} + a_n \log n_{it} + a_{ext} ext_{it} + a_\theta (\widetilde{\theta}_{it} * K) + \varepsilon_{it} + \omega_i \tag{15}$$

It is likely that the proportions of members in cooperatives, extension and ethnic groups are correlated to some unobservable local features (think for example at some characteristics resulting from the history of the village). As far as these effects are timeinvariant (as they are likely to be at least in the short time span available for the analysis) the fixed effect technique will enable us to control for such differences which will not, therefore, bias the point estimates.

## 7 The results

Table 6 summarizes the results of the fixed effects regression for the first specification, where K can take only discrete values. Column one and two report the results for the non-ethnic based definition of the probability, as in equation (11). The difference between the two columns is the following: while in the first one the probability variable incorporates the result due to direct extension (in other words extension members have a probability of knowing equal to one), the second column splits the variable in two, the direct effect of extension and the effect of the probability of knowing for people who are not in extension. The results in column one indicate that there is a strong effect of the probability of knowing for the food crops, with a coefficient of 0.616. Once we split the probability variable, though, we observe that while the direct extension coefficient stays positive and significant (with coefficient implying an elasticity around 60%[14], in line with the results obtained in Romani 2002) the network coefficient does not stay significant. This result therefore excludes an effect linked to the exchange of information between extension members and non-extension members through the networks . In columns 3 and 4 we repeat the exercise but now defining probabilities along ethnic lines as in equation (13). Column 3 reports the result incorporating the direct extension effect in the probability variable. Again the probability seems to be associated with higher output levels for food crops, with a coefficient varying between 1.13 for the dominant ethnic group to 0.69 for the non

[14] the formula used to obtain the elasticity to extension is the following: $100*g = 100*\{\exp(c)-1\}$ were $g$ is the relative effect (so that $100*g$ is the percentage effect, and $c$ is the estimated coefficinet for the dummy variable). See Halvorsen and Palmquist (1990) for details about the calculation of dichotomous variables elasticity in a semi logarithmic setting.

autochthonous ethnic groups. Once we split the result between extension and probability of knowing (for people not in extension) the direct extension effect for food crops stays positive and significant (with the usual coefficient implying an elasticity of 60%), but there is no evidence of any effect linked to the exchange of information between extension members and non members within each ethnic group. Basically we cannot identify any network effect when we define knowledge as a dichotomous variable.

In Table 7 we proceed to relax the assumption on K being discrete and we adopt the model where knowledge is a stock variable (as described in equation 14). We carry out similar tests, but now the probability variables will represent the expected knowledge, and take values between 0 and K. The results reported in column 1 indicate that once we split the variable into a direct extension effect and an expected knowledge effect for farmers not in extension, the coefficient associated with expected knowledge for food crops stays significant (now at the 5% level) and positive, with a magnitude of 0.109. Notice that this result does not supplant the effect of direct extension, which stays basically unchanged with a coefficient implying an elasticity of about 60%. This result provides evidence that there is an exchange of information going on between extension members and non-members within the network. Do all neighbours exchange the same amount of information regardless of their ethnic origin? To answer this question we proceed to test the final model proposed, where the expected knowledge variable is defined along ethnic lines, as described by equation 15. Column 3 reports the result where we distinguish between the direct extension effect and the expected knowledge effect, now defined for each ethnic group separately. Again we find the familiar result for direct extension on food crops (with the usual elasticity a little above 60%); the result for expected knowledge is also positive and significant, with a coefficient of 0.116 for non-indigenous farmers but non-significant for the ethnic autochthonous ones. This result suggests that farmers belonging to ethnic minorities who are excluded from extension services benefit from exchanging information with their ethnic peers who are members of extension. So, even if these farmers are not as likely as farmers belonging to the dominant ethnic group to be extension members, they have a way of accessing and benefitting from the information that reaches their communities.[15] Column 4 of Table 7 provides an additional test to our theory. Here we define total knowledge available in the village along ethnic lines, i.e. summing up the presence of extension separately for indigenous and non-indigenous farmers. In this specification we want, therefore, to assign to farmers in a specific ethnic group only the knowledge stock available in their own ethnic group. This is particularly important for the ethnic minority, given the discrimination they face in accessing knowledge. The results do not change significantly from the pervious ones, confirming the presence of a network effect within non-indigenous farmer groups.

Two potential identification problems remain to be addressed. It maybe possible that non autochthonous farmers rely on their ethnic piers to access extra workforce in moments of need. It is not clear whether this effect may be channelled through the cooperative membership. Should this be the case, the cooperative-network variable might be correlated with this source of extra labour, introducing an alternative explanation for the positive coefficient of the network variable in the ethnic specific setting (table 7). To address this problem we use information available from the cross-sectional survey of 1997. Table 8 shows the sources of hired workforce for farmers belonging to the autochthonous and non-autochthonous groups, and for members and non members of cooperatives. While it is clear from the table that non-autochthonous farmers rely more on non-autochthonous workers (as suggested by Ruf, 1995) it is not evident that membership in cooperatives amplifies this behaviour.

[15] This result is robust to other specifications which were tested, notably to redefining the production function in terms of output values, using price information. The results were also tested for robustness using, when considering knowledge as a stock variable, a total knowledge variable instead of a direct extension dummy to control for extension effect. These additional results are available from the author.

The second potential identification problem concerns the limits of fixed effects models. As already mentioned, if the variation in efficiency observed is linked to an unobservable dynamic effect correlated to the ethnic-network variable, then fixed effects will not be sufficient to guarantee identification. While it is not easy to think of such an effect, this remains a limitation. Due to the short nature of this panel it is not feasible to apply multiple-differencing techniques to control for such effects. Once additional data is available this would be a natural further step to understand the mechanisms of information sharing.

# 8 Conclusions

This paper investigates the role of knowledge networks in determining yields. In particular we investigate the role of social proximity, interpreted not only as physical vicinity but also as ethnic similarity among neighbours. To do so we defined the probability as knowing a neighbour who has access to the knowledge, which was diffused to some farmers only in the community by an extension agent. Such probability is identified by three characteristics: geographical vicinity, membership in a network organization and the extent to which people are ready to share with their neighbours. To proxy these variables we used a panel dataset collected in Côte d'Ivoire in the period between 1997 and 2000 and containing detailed information on agricultural production, on membership in organizations and institutions and on the ethnic origins of farmers. The latter is used to define "social proximity", and hence the farmer's willingness to share knowledge with neighbours. We test two distinct models first treating knowledge as a dichotomous variable and then as a stock variable, which increases proportionally with the amount of extension services offered in the community. We use a panel data fixed effects methodology to identify this effect.

The following conclusions can be derived from the results: first non autochthonous farmers are less likely to become members of extension services. Secondly, unlike their neighbours belonging to the autochthonous ethnic group, they benefit significantly - in terms of higher yields in food crops - from exchanging information among themselves. This result is true only when we define knowledge as an accumulable stock variable, a hypothesis which seems reasonable in the Ivorian context. More work is necessary to identify the workings of this sort of re-equalization mechanism adopted by the ethnic minorities. In particular future work should look at whether this ethnic network effect is still present in areas where there is no bias against non autochthonous farmers' access to knowledge through extension.

## 8.1 Appendix 1 - Sampling methods and survey structure

The data used for this analysis come from a survey carried out by ANADER, a specialized agency of the ministry of agriculture of the government of Côte d'Ivoire. The project had two phases. In 1996/1997 a first survey was carried out with the aim of collecting information about the production capability, marketing facilities and standard of living of a nationally representative sample of farmers in the country. 262 localities were selected randomly and 25 or 50 households were surveyed within each locality selected (according to the size of the locality extracted, see following table). The sample was stratified by region (there are 10 regions) and the primary sampling units (PSUs - the village/location) were selected independently in each region. Census lists were created for each selected PSU and households were then selected randomly from the list.

| Area | number of localities | number of households |
|---|---|---|
| Sud | 41 | 2050 |
| Sud-Ouest | 21 | 1800 |
| Centre | 36 | 400 |
| Centre-Nord | 16 | 1200 |
| Centre-Est | 20 | 1000 |
| Centre-Ouest | 24 | 600 |
| Ouest | 24 | 750 |
| Nord | 30 | 600 |
| Nord-Est | 24 | 650 |
| Nord-Ouest | 26 | 1050 |
| **Total for C.I.** | 262 | 10100 |

A sub-sample was then selected from the original nationally representative sample with the aim of collecting more detailed information on productivity. The farmers were selected randomly starting from the original sample. A replacement list was created to allow for drop-out for the re-survey in subsequent years. Enumerators received detailed instructions on land surface and quantity measurement. Information on crop density, access to extension services and membership in rural organizations was also collected. A section of the questionnaire was also dedicated to animal husbandry, but unfortunately the data from this section is available only for one year. No detailed information was collected on variable inputs such as labour and fertilizers. The following table summarizes the number of localities selected and the number of households in each area. For additional details on the structure of the survey see ANADER (2001).

| Area | number of localities | number of households |
|---|---|---|
| Sud | 40 | 410 |
| Sud-Ouest | 18 | 200 |
| Centre | 21 | 210 |
| Centre-Nord | 34 | 360 |
| Centre-Est | 13 | 160 |
| Centre-Ouest | 24 | 240 |
| Ouest | 24 | 120 |
| Nord | 28 | 150 |
| Nord-Est | 24 | 120 |
| Nord-Ouest | 24 | 130 |
| **Total for C.I.** | 250 | 2100 |

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Table 1. Descriptive statistics.

Cocoa

| | | Ave. Output | Ave. Tot. land surf. | Ave. Density (stems/ha) | Ave. yields |
|---|---|---|---|---|---|
| 1998 | Mean | 2861.9 | 2.9 | 1034.5 | 943.9 |
| | Median | **2010.5** | **2.3** | **1022.1** | **888.8** |
| | Std. Dev. | 2305.5 | 2.4 | 315.4 | 341.7 |
| 1999 | Mean | 2136.4 | 3.1 | 982.8 | 542.2 |
| | Median | **1476.8** | **2.2** | **977** | **453.3** |
| | Std. Dev. | 2081.9 | 2.6 | 352.1 | 277.6 |
| 2000 | Mean | 1405.2 | 1.9 | 968.9 | 622.4 |
| | Median | **966.4** | **1.3** | **977** | **586.7** |
| | Std. Dev. | 1493.2 | 1.7 | 361.8 | 295.4 |

Coffee

| | | Ave. Output | Ave. Tot. land surf. | Ave. Density (stems/ha) | Ave. yields |
|---|---|---|---|---|---|
| 1998 | Mean | 1840.5 | 2.6 | 909.1 | 371.1 |
| | Median | **1530** | **2.1** | **844.4** | **357.8** |
| | Std. Dev. | 1166.2 | 1.5 | 278.9 | 124.35 |
| 1999 | Mean | 1973.1 | 2.8 | 911.1 | 327.2 |
| | Median | **1592.9** | **2.3** | **888.9** | **333.35** |
| | Std. Dev. | 1557.5 | 2.1 | 324 | 145.45 |
| 2000 | Mean | 1499.1 | 2.4 | 836.2 | 328.5 |
| | Median | **1002.4** | **1.8** | **800** | **346.65** |
| | Std. Dev. | 1475.8 | 2 | 257.5 | 145.8 |

Rice

| | | Ave. Output | Ave. Tot. land surf. | Ave. yields |
|---|---|---|---|---|
| 1998 | Mean | 1421.7 | .88 | 1590.6 |
| | Median | **1237.5** | **.77** | **1625** |
| | Std. Dev. | 862.6 | .54 | 366.7 |
| 1999 | Mean | 1846.3 | .96 | 1756.9 |
| | Median | **1350** | **.83** | **1812.5** |
| | Std. Dev. | 1490.1 | .54 | 776.4 |
| 2000 | Mean | 1655.1 | .86 | 1435.9 |
| | Median | **1232.8** | **.76** | **1406.25** |
| | Std. Dev. | 1340.8 | .49 | 441.5 |

Yam

| | | Ave. Output | Ave. Tot. land surf. | Ave. yields |
|---|---|---|---|---|
| 1998 | Mean | 6687.9 | .43 | 12534.2 |
| | Median | **5019.6** | **.33** | **11500** |
| | Std. Dev. | 4780.9 | .30 | 3204.2 |
| 1999 | Mean | 6890.4 | .46 | 1462.9 |
| | Median | **6057.9** | **.40** | **13700** |
| | Std. Dev. | 4914.3 | .28 | 7351.7 |
| 2000 | Mean | 6121.9 | .50 | 9984.75 |
| | Median | **5324** | **.41** | **10045** |
| | Std. Dev. | 4232.6 | .30 | 2782.5 |

Table 2 - ethnic origin by region

| Region | indigenous | non-indigenous | foreign |
|---|---|---|---|
| | % | | |
| North | 95.25 | 4.04 | 0.71 |
| North East | 80.63 | 5.33 | 14.04 |
| North West | 86.06 | 10.70 | 3.24 |
| West | 84.72 | 6.70 | 8.58 |
| Centre | 79.88 | 8.84 | 11.28 |
| Centre-North | 88.24 | 7.83 | 3.93 |
| Centre-East | 35.23 | 24.55 | 40.23 |
| Centre-West | 44.59 | 23.90 | 31.52 |
| South-West | 17.69 | 43.08 | 39.23 |
| South | 56.62 | 16.93 | 26.45 |

Table 3 - Access to extension by ethnic origin

| % member in extension | autochth. | non-authoch. |
|---|---|---|
| 1998 | 19.6 | 32.7 |
| 1999 | 34.7 | 36.3 |
| 2000 | 25.6 | 36.7 |

Table 3.1 - Probit regression: determinants of the probability of being a member of extension services.

| | *dF/dX* |
|---|---|
| | membership in extension |
| years of education | .003 |
| | 0.302 |
| land surface | -.001 |
| | 0.169 |
| **farmer from non-autochthonous ethnic group** | **-.051**** |
| | 0.018 |
| partic. org 1: | -0.48 |
| common production group | 0.526 |
| partic. org 2: | 0.80*** |
| marketing group | (0.000) |
| partic. org 3: | 0.153*** |
| cooperative | (0.001) |
| partic. org 4:. | .279 |
| trade union | (0.374) |
| partic. org 5: | .046 |
| other groups | (0.499) |
| number of household members | .002 |
| | (0.260) |
| Female household head | .004 |
| | (0.915) |
| Tot. observations | 3364 |

$dF/dx$ is for discrete change of dummy variable from 0 to 1; informal arrangements is the omitted category in the participatory organizations variables; spatial and temporal dummies are omitted. $P > |z|$ (reported in parenthesis) are the test of the underlying coefficient being 0; *significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4 - Fixed effect production function: with ethnic interactions.

| | with interaction for crops and ethnic origin |
|---|---|
| | ln(crop specific output) |
| ln(crop specific plot surf.) | 1.38*** |
| | 0.000 |
| ln(workforce) | .118** |
| | 0.070 |
| **direct extension:** | |
| **on food for autochthonous ethnic group** | **.502*** ** |
| | **0.000** |
| **on food for non-autochthonous ethnic group** | **.396*** ** |
| | **0.007** |
| **on perennials for autochthonous ethnic group** | **.031** |
| | **0.789** |
| **on perennials for non-autochthonous ethnic group** | **.055** |
| | **0.688** |
| Tot. observations | 1131 |
| Panel individuals | 506 |
| average obs. per panel | 2.6 |
| R-squared | 0.7416 |

Notes: Ln(output) is the dependent variable. Spatial and crop dummies are not reported (available from the author). $P > |t|$ in parentheses; *significant at 10%; ** significant at 5%; *** significant at 1%

Table 5 - Cross section production function with ethnic control variable.

| | food | perennials |
|---|---|---|
| | ln(output) | |
| ln(crop specific plot surf.) | .893*** | .956*** |
| | (0.000) | (0.000) |
| ln(work force) | .081*** | .045** |
| | (0.002) | (0.030) |
| ln(fertilizers quantity) | .026 | .124** |
| | (0.254) | (0.034) |
| ln(pesticides quantity) | .060* | .252*** |
| | (0.087) | (0.000) |
| **ethnic dummy** | **.034** | **-.308*** ** |
| **(0=non-indigenous;1=indigenous)** | **(0.757)** | **(0.009)** |
| young trees dummy | - | -1.167*** |
| (0 if age>5; 1 otherwise) | - | (0.000) |
| years of educ. of hh head | .015 | -.025*** |
| | (0.191) | (0.000) |
| Sex of the hh head | -.130 | -.309 |
| (0=male;1=female) | (0.191) | (0.025)** |
| Tot. observations | 9769 | 6726 |
| R-squared | 0.30 | 0.3137 |

Notes: Ln(output) is the dependent variable. Spatial and crop dummies are not reported (available from the author). $P > |t|$ in parentheses; *significant at 10%; ** significant at 5%; *** significant at 1%

Table 6 - Network effects on productivity - discrete K regressions.

| | | (1) | (2) | (3) | (4) |
|---|---|---|---|---|---|
| | | Without ethnic element | | With ethnic element | |
| | | crop specific ln(output) | | | |
| ln(crop specific plot surf.) | | 1.35*** | 1.35*** | 1.32*** | 1.35*** |
| | | 0.000 | 0.000 | 0.000 | 0.000 |
| ln(hhsize) | | .316 | .593 | .184 | .601 |
| | | 0.652 | 0.380 | 0.794 | 0.375 |
| direct extension for perennials | | - | **.015** | - | **.022** |
| | | - | **0.882** | - | **0.827** |
| direct extension for food crops | | - | **.474*****  | - | **.469***** |
| | | - | **0.000** | - | **0.000** |
| **probability of knowing a neighbour who knows:** | **effect for perennials** | **-.043** | **-.556** | - | |
| | | **0.753** | **0.169** | - | |
| | **effect for food crops** | **.616***** | **.037** | - | |
| | | **0.000** | **0.928** | - | |
| | For perennials and autochthonous ethnic group | - | - | **.077** | **-.844** |
| | | - | - | **0.711** | **0.153** |
| | For perennials and non-autochthonous ethnic group | - | - | **.221** | **-.467** |
| | | - | - | **0.401** | **0.574** |
| | For food crops and autochthonous ethnic group | - | - | **1.13***** | **-.411** |
| | | - | - | **0.000** | **0.509** |
| | For food crops and non-autochthonous ethnic group | - | - | **.692***** | **.518** |
| | | - | - | **0.009** | **0.575** |
| Tot. observations | | 1225 | 1311 | 1225 | 1311 |
| Panel individuals | | 468 | 506 | 468 | 506 |
| average obs. per panel | | 2.6 | 2.6 | 2.6 | 2.6 |
| R-squared | | .7432 | .7417 | .7436 | .7419 |

Notes: Ln(output) is the dependent variable. Spatial and crop dummies are not reported (available from the author). P>|t| in parentheses; *significant at 10%; ** significant at 5%; *** significant at 1%

Table 7 - Network effects on productivity - expected knowledge regressions.

| | | (1) Without ethnic element | (2) With ethnic element | (3) With ethnic element, ethnic specific k |
|---|---|---|---|---|
| | | crop specific ln(output) | | |
| ln(crop specific plot surf.) | | 1.38*** | 1.38*** | 1.38*** |
| | | 0.000 | 0.000 | 0.000 |
| ln(lab) | | .127** | .128** | .129** |
| | | 0.051 | 0.048 | 0.047 |
| direct extension for perennials | | **.097** | **.092** | **0.96** |
| | | **0.336** | **0.361** | **0.342** |
| direct extension for food crops | | **.531*** ** | **.527*** ** | **.531*** ** |
| | | **0.000** | **0.000** | **0.000** |
| **Expected knowledge** | | | | |
| | **effect for perennials** | **.085** | | |
| | | **0.256** | | |
| | **effect for food crops** | **.109** ** | | |
| | | **0.042** | | |
| | **for perennials and autochthonous ethnic group** | - | **-.068** | **-.067** |
| | | - | **0.696** | **.699** |
| | **for perennials and non-autochthonous ethnic group** | - | **.114** | **.159** |
| | | - | **0.176** | **0.140** |
| | **for food crops and autochthonous ethnic group** | - | **.004** | **.005** |
| | | - | **0.983** | **0.982** |
| | **for food crops and non-autochthonous ethnic group** | - | **.116** ** | **.191*** |
| | | - | **0.043** | **0.053** |
| Tot. observations | | 1285 | 1284 | 1284 |
| Panel individuals | | 501 | 500 | 500 |
| average obs. per panel | | 2.6 | 2.6 | 2.6 |
| R-squared | | 0.7486 | 0.7487 | 0.7486 |

Notes: Ln(output) is the dependent variable. Spatial and crop dummies are not reported (available from the author). P>|t| in parentheses; *significant at 10%; ** significant at 5%; *** significant at 1%

Table 8. Sources of hired workforce by ethnic origin and membership in cooperative.
% of workforce hired from ethnic group:

| | | | Member in cooperative | |
|---|---|---|---|---|
| | | | No | Yes |
| | Autochth. | Autochthonous | 52.8 | 60.6 |
| Farmer's Ethnic group | | Non-autochthonous | 47.2 | 39.4 |
| | Non-autochth | Autochthonous | 8.0 | 11.4 |
| | | Non-autochthonous | 92.0 | 88.6 |