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Imperfect Markets: a Case Study in Senegal

by

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Abstract

Farmers in developing countries are confronted with imperfect markets. This has an impact on their production activities. When implementing developing projects these market imperfections should be taken into account. This paper is an attempt to discuss the impact of imperfect markets in the context of an irrigation project in village Pata, Senegal. The first section models the production decision of the agricultural household. The second section presents the irrigation project in Pata. The third section tests for the presence of imperfections in the credit and labour markets of Pata. I conclude by discussing the implications for the project.

Introduction

Imagine 28 farmers of a small village who receive plots of an equal size. The farmers are at the same time taught how to cultivate bananas, a fruit they have never cultivated before. They all receive the same banana plants and plant them in the same way. The farmers organize as a co-operative. This co-operative manages the irrigation system and the commercialisation of the bananas. Each farmer has to provide labour and fertiliser for his plot. Neo-classical economic theory predicts that all farmers will take the same production decisions if all markets operate perfectly. In this case, they will use the same labour and fertiliser inputs. Obviously, if soil quality is not very different, the farmers will have more or less the same yields. Suppose now that we observe large differences in yields.

The first section will show that two main causes of these differences could be imperfections in the labour and credit markets. I proceed by presenting the production decision of the household first in a model with perfect markets, then in a model with an imperfect labour market and finally in a model with an imperfect credit market. The second setion presents the irrigation project in Pata, of which the setting corresponds to our imaginary situation. The third section tests for the presence of market imperfections in Pata. To conclude, I discuss the consequences of the imperfections for the working of the irrigation project.

1. The household production decision

1.1. Perfect markets

The large majority of rural households in developing countries organise their production activities within the household. Therefore we integrate the production, consumption and labour decisions in one model. The objective function of this model can be written as follows:

$$Max_{q_a, x, l, c_a, c_m, c_l}\, u\left(c_a, c_m, c_l; z^h\right) \qquad \text{(I.1)}$$

With u(.) a twice differentiable convex utility function
q_a the agricultural production of *a* within the household
l the production factor labour
x the production factor fertiliser
c_a the household consumption of farm products *a*
c_m the household consumption of market goods *m*
c_l the consumption of leisure and time for reproductive activities
z^h a vector of household features, e.g. household size and cattle ownership

So, the household takes decisions regarding its consumption (c_a, c_m, c_l) and its production (q_a, x, l). The household utility depends on its consumption and is affected by the features of the household (z^h). For example, a household with many young children or siblings could prefer more reproductive activities to productive activities. The objective function is resricted by three constraints:

$$g(q_a, x, l; z^q) = 0 \qquad \text{(I.2)}$$

$$p_m c_m + p_a c_a + p_x x + wl = p_a q_a + wl^s + y \qquad \text{(I.3)}$$

$$c_l + l^s = T(z^h) \qquad \text{(I.4)}$$

The first restriction is a twice differentiable production function. The production (q_a) depends on variable production factors (x, l) and on fixed production factors (z^q), e.g. the irrigation system and the size of the agricultural activities. The second and third restrictions are the budget and time constraint. The purchase of consumption goods (c_a, c_m), and the purchase of production factors (x, l) has to be financed with household income. This income is determined by the labour income of the household members (wl^s), the agricultural proceeds of the household ($p_a q_a$) and exogeneous income (*y*). The time endowment (T) depends on household features (z^h), such as household size and composition and can be used for the labour supply of the household members (l^s) leisure and time for reproductive activities (c_l).

Suppose now that the household can purchase all production factors, such as labour, on the market place and that it can supply her own labour on that market place. Suppose further that there exists a market where the household can buy m and buy and sell a and that there exists a credit market where the household can unlimitedly borrow or lend money. In short, imagine that there are markets for all goods and factors. If we assume exogeneous prices, i.e. prices that are independent of the decisions and features of the household, we can treat the maximisation problem (I.1) of the household as the result of two separate decisions: the production decision on the one hand and the labour and consumption decision on the other (*Source*: Sadoulet, E., De Janvry, A. (1995)). In that case, the input of labour (*l*) and fertiliser *(x)* will be independent of the preferred labour supply of the household and of the household income, and the choice of q_a (the household agricultural production) will be independent of the household preference for a or m. Therefore, the maximisation problem can be solved in two seperate steps. In the first step we solve the production problem. The household maximises its profit given the production function:

$$Max_{q_a,x,l} p = p_a q_a - p_x x - wl \tag{I.5}$$
$$s.t.$$
$$g(q_a, x, l; z^q) = o$$

In a second step, we maximise household utility by solving for household labour supply and consumption given the maximised profit π*, the budget and the time constraint:

$$Max_{c_a,c_m,c_l} u\left(c_a, c_m, c_l; z^h\right) \tag{I.6}$$
$$s.t.$$
$$p_x x + p_m c_m + wc_l = p^* + wE + y$$
$$c_l + l^s = T(z^h)$$

So, the result of this neo-classical model is that in the presence of perfect markets, we can analyse the production decision (I.5) independently of the household features (z^h). What does this result imply for the production in our imaginary situation? The plots have the same size and the farmers have the same access to infrastructure and technology. The neo-classical model predicts that the proceeds will only depend on the differences in soil quality between the plots. Our empirical analysis will not support this prediction. Therefore we introduce first a labour market imperfection in our model and then a credit market imperfection.

1.2. An imperfect labour market

We adapt model (I.1 - I.4) in order to analyse imperfections in the labour market (*Source*: Benjamin (1992)):

$$Max_{q_a, x, L^O, L^H, L^F, c_a, c_m, c_l} u\left(c_a, c_m, c_l; z^h\right) \quad \text{(I.7)}$$

$$s.t.$$

$$g\left(q_a, x, l^d; z^q\right) = 0 \text{.....} with \text{.....} l^d = L^F + L^H$$

$$p_m c_m + p_a c_a + p_x x + wL^H = p_a q_a + wL^O + y$$

$$c_l + l^s = T(z^h) \text{.....} with \text{.....} l^s = L^O + L^F$$

Household labour (l^s) is split up in labour on the family farm and off-farm labour ($L^F + L^O$). The labour used for the production of *a* (l^d), is the sum of household labour on the family farm and hired labour ($L^F + L^H$). The price of both hired labour and off-farm labour is equal to the market wage (*w*). We assume that decisions concerning the household structure are exogeneous. Graph I.1. presents the equilibrium of a household in a perfect labour market. The household maximises the agricultural profits independently of its preferences. As a consequence, farmers faced with the same production function and the same price choose the optimal labour supply $l^* = l^d$. The equilibrium condition for profit maximisation is:

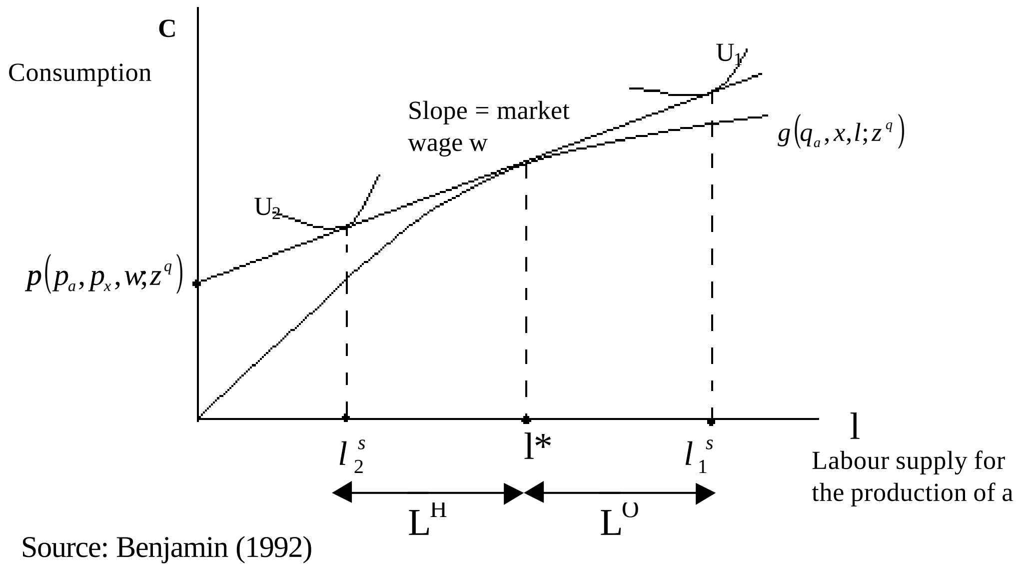
$$\frac{d\left[g\left(q_a, x, l^d; z^q\right)\right]}{dl^d} = w \quad \text{(I.8)}$$

Graph 1.1. Illustrates two possible scenarios. The labour supply of the household with utility U_1 is larger than the optimal labour supply, $l_1^s > l^*$. This implies that the household members also work off-farm, $L^O > 0$. For household preferences U_2 the household hires in labourers for the production of the agricultural good *a*, so $L^H > 0$.

We can now analyse the consequences of a restriction on the hiring of labourers. This is a typical situation for the peak season. In the off-peak season we will rather observe limited off-farm labour demand as an imperfection. We are not discussing this latter type of imperfection because we deal with a peak moment in the empirical section. The household labour supply (l^s) depends on the time endowment ($T(z^h)$) and on the preferred amount of leisure (c_l). Suppose leisure is a function of the market wage (*w*), the income $M(y + \pi + wT(z^h))$, and the household features (z^h). In that case we can write the household labour supply as follows:

(I.9)

Graph 1.1. : The labour allocation decision in a perfect labour market



Source: Benjamin (1992)

$$l^S\left(w, M; z^h\right) = T(z^h) - c_l\left(w, M; z^h\right)$$

The optimal labour demand for production on the family farm:

$$l* = l*\left(w, p_a, p_x; z^q\right) \tag{I.10}$$

However, suppose now that the amount of labour hired in is limited to $\overline{L}$, then the following situation may prevail:

$$l*\left(w, p_a, p_x; z^q\right) > l^s\left(w, M, z^h\right) + \overline{L} \tag{I.11}$$

The houshold labour demand is larger than household labour supply plus available labour supply on the market. The farmer allocates labour to the family farm until demand and supply equalise for the shadow wage w*:

$$l^d = l**\left(w*; z^q\right) = l^s\left(w*, M*, z^h\right) + \overline{L} \tag{I.12}$$

In contrast to the result of a perfect labour market, the labour used on the family farm depends on the preferences of the household features (z^h) and is smaller than the labour used when there is no restriction on hired labour (l*). In this scenario of an imperfect labour market, we can formally derive how the household composition (z^h) influences the labour allocation (l^d). The relevant derivative is dl^d/dz^h. Under the assumption of exogeneous prices p_a and p_x, the demand for labour on the household farm can be written as (*Source*: Strauss, J. (1986), Neary, J., P.and Roberts, K. (1980):

$$l^d = l^*\left(w^*, p_a, p_x; z^q\right) = -\frac{dp\,(w^*, p_a, p_x; z^q)}{dw^*} \tag{I.13}$$

The derivative with respect to z^h is:

$$\frac{dl^d}{dz^h} = -p_{11}\frac{dw^*}{dz^h} \tag{I.14}$$

The labour demand is a non-increasing function of the wage, such that $p\left(w^*; z^q\right)$ is a convex function. As a consequence $-p_{11} < 0$. The sign of dw^*/dz^h is not determined. For example, if household size increases the extra labour supply should be compared with the extra demand for leisure. For a net increase of the labour supply the shadow wage decreases, so dw^*/dz^h will be negative, such that dl^d/dz^h will be positive. In that case the model predicts that households bounded by restriction (I.11) will supply more labour as household size grows. On the basis of this result the third section will test if the labour market in Pata is characterised by a restriction on hiring labour.

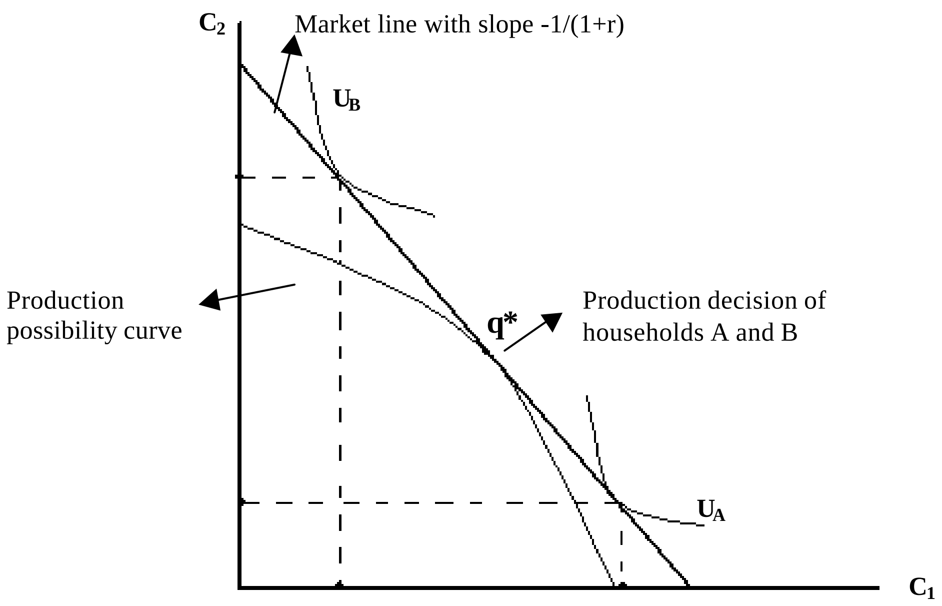
1.3. An imperfect credit market

In a perfect credit market an economic agent can borrow as much money as he likes at a unique interest rate. Suppose for example that a farmer in a two period world borrows the amount B_c. His budget restriction for the first period will be:

$$p_m c_m + p_a c_a + p_x x + wL^H = p_a q_a + wL^O + y + B_c \tag{I.14}$$

In the second period the farmer has to pay back the loan. If i is the nominal interest rate, the farmer will have to pay back the amount $B_c(1+i)$. For a production credit, the farmer borrows money until the last invested FCFA (The Senegalese currency) pays off exactly as much as the loan of one FCFA, i.e. the market interest rate (If consumption credit is considered, the farmer borrows money until the market interest rate equals his time preference for consumption). Since a perfect credit market is characterised by a unique market interest rate farmers with similar production possibilities will take the same production decisions, no matter what their preferences are. This is illustrated in graph 1.2. for a two period world. The horizontal and vertical axes show the consumption of goods, respectively in period one and two. The concave curve represents the production possibilities of the farmer. The tangent line to this curve represents the pay-off of productive investments. The budget restriction is captured by the straight line with slope -1/(1+r), the unique market interest rate. Finally, utility is represented by the convex indifference curves.

Graph 1.3. : The production and consumption decision in a perfect credit market



Source: Fisher, I. (1930)

The economic agents A and B have different preferences represented by the indifference curves, U_A en U_B. Yet, we find that they take the same production decision q*, the point where the marginal pay-off of an extra investment equals the market interest rate. So as with perfect labour markets, with a perfect credit market the production and consumption decisions are recursive. In what follows we show how imperfections in the credit market influence the production decision. Therefore we make a distinction between the ex ante and ex post access to credit (*Source*: Carter, M., R. and Wiebe, K., D. (1990)). The ex ante access indicates the possibility of financing the production factors labour and fertiliser, i.e. the working capital. Ex post, access to credit is important as an insurance for the case of bad luck, such as a bad harvest. In that case the farmer may take up a consumption credit to guarantee the household food security.

a. Ex ante capital access In an imperfect credit market not every farmer will choose point q* on graph 1.3. On the one hand it is possible that a farmer cannot borrow as much money as he would like, on the other it is possible that farmers have to pay different interest rates such that the opportunity cost of their investments are not similar. Suppose there is a unique interest rate, but no unlimited credit line. Then we add the following restriction to our model[1]:

$$B_c \leq B(z^h) \tag{I.16}$$

B_c is the borrowed amount of money at the market interest rate. B is the maximum amount of money that can be borrowed. B depends on the features of the household.

This will be illustrated in section three with the help of household level data. The restriction is binding if the desired amount of money is larger than the maximum B. In that case the Lagrange multiplier of this restriction, μ will be larger than zero. First order optimality conditions are:

$$p_a \frac{dq_a}{dL^H} = (1 + m)w$$

$$p_a \frac{dq_a}{dx} = (1 + m)p_x \qquad \text{(I.17)}$$

The mark-up μ will be higher to the extent that B_c is larger than B. So, farmers with a more binding restriction will have a higher shadow price for the inputs and if we assume that the marginal proceeds of the inputs are the same across plots, these farmers will use less of the inputs. This hypothesis will be tested in the third section.

b. Ex post capital access After choosing production q* in the perfect credit market of graph 1.2, the farmer could perform transactions on the credit market to determine his consumption level in period one and two. However, in the presence of a credit limit, these transactions are limited. Therefore, the farmer will take into account his consumption preferences while making his investment decision. For example, the economic agent B will choose a point on the production possibility frontier that is more to the left of q*, closer to his consumption preference. So, in developing countries, where household food security has to be guaranteed with limited credit or insurance possibilities, there is a trade-off between the most efficient production choice and food security. The more stringent the credit restriction, the more risk averse the household will be (*Source*: Esweran and Kotwal (1990)). To understand the risk behaviour of poor agricultural households it is important to distinguish between two strategies (*Source*: Decon (1996)). First, there is the risk coping strategy, like the sale of cattle. This strategy is used after the adverse shock has taken place. When the shock is at the village level the strategy is not always as accurate. Imagine for example that several households want to sell cattle at the same time. Obviously prices will plummet. A second strategy is the so-called risk management strategy. Some well-known examples are the diversification of activities and the choice of less risky crops even if these are less productive. We will introduce this latter risk management strategy into our model[2]. The farmer has the choice between two crops, *a* and *m*. Crop *m* has high but insecure yields, crop *a* has low but relatively secure yields. The land allocation is presented by T_a en T_m. The farmer can use labour and fertiliser for both cultures. M* is the critical household income. When the income is lower than M*, household food security is threatened. Every farmer maximises his utility under the condition that the chance that the food security is at stake is smaller than the constant α[3].

$$Max_{B_c, q_a, q_m, x_a, x_m, L^O, L^H_a, L^H_m, L^F_a, L^F_m, T_a, T_m, c_a, c_m, c_l} u\left(c_a, c_m, c_l; z^h\right) \quad \text{(I.18)}$$

$$\begin{aligned}
&o.v.v.\\
&g\left(q_a, x_a, L^H_a + L^F_a, T_a; z^{q'}\right) = 0\\
&f\left(q_m, x_m, L^H_m + L^F_m, T_m; z^{q'}\right) = 0\\
&T_a + T_m = T\\
&p_m c_m + p_a c_a + p_x x_a + wL^H_a + p_x x_m + wL^H_m = p_a q_a + p_m q_m + wL^O + y + B_c\\
&B_c \leq B(z^h)\\
&c_l + L^O + L^F_a + L^F_m = E\\
&\Pr(p_a q_a + p_m q_m + wL^o + y + B(z^h) < M^*) < a
\end{aligned}$$

Without formally solving this model, we can see that the extra restriction shows that a farmer with a larger credit line $B(z^h)$, more exogeneous income (y) or more off-farm income (wL°), will be able to take up more risk in his agricultural production decisions. A farmer with limited risk coping and management abilities will allocate some more land and labour to the less yielding but less risky culture *a*. However, we cannot ignore that there can be other reasons for the choice of *a*, e.g. differences in access to technology, in education and experience of the farmers, in the required working capital and access to credit. For example if the cultivation of *a* requires more fertiliser, the opportunity cost of cultivating *a* will be higher for a farmer with little credit access than for a farmer who has unlimited access to credit. Also an imperfect labour market can explain the choice for *a*. For example, if the cultivation of *m* is very labour demanding, the household might opt for *a* if there is a limited supply of labour in the market. It will be a challenge in our third section to take into account these possibilities. But before turning to the empirics, the next section briefly presents the irrigation project of Pata.

2. The irrigation project in Pata

In '93 the Belgian NGO VECO started an irrigation project in village Pata in the South of Senegal. Since '97, The daily management of this project has been in the hands of a Senegalese NGO, FODDE (Forum pour un Développement Durable Endogène). The project of VECO-FODDE is situated in the Kolda region, the most rural region in Senegal. The irrigation project is meant as an alternative for the extensive peanut culture. Due to the high birth rates and the immigration from the north of Senegal, the population pressure rises and the traditional extensive peanut culture expands. This evolution endangers the ecosystem. Irrigating creates new sources of income and fights the dryness and erosion. Furthermore, the introduction of bananas and a gamut of vegetables offers a new source of vitamins to the village population. In addition, a succesfull irrigation project can make the rural live more attractive, also for youngsters.

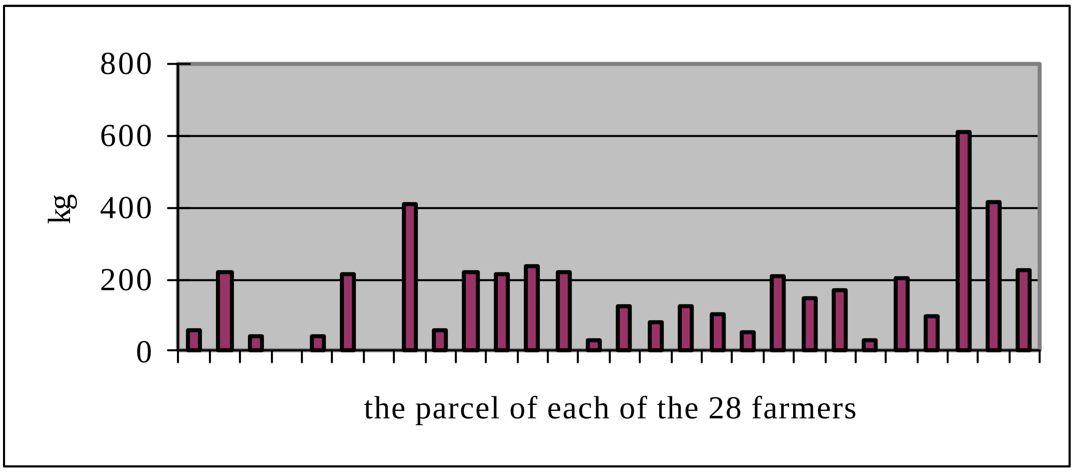
The fruit and vegetables cultivated on the irrigated fields are designated for the market. Only a small part of the lowest quality is being used for household consumption. Selling the output is managed by a co-operative, a “Groupement d’Intérêt Economique” (GIE). This GIE should also organise the purchase of fertiliser, plants, seed and other inputs. All members of the GIE divide the proceeds of the area. Every member farmer receives the net-proceeds of his own irrigated plot[4]. A part of the proceeds is used to pay off the funding capital. However, these payments are not paid to VECO, but are transferred to a village fund. The village can use this fund to finance other projects, like the youth house, the health post and the sewer system. In this way, the irrigation project is meant as a catalyst for the development of the village. For this scheme to work it is indispensable that the agricultural activities in the area generate a profit.

Yet, from ‘96 on the finances of the GIE are going downhill. In ’96 the motor of the water pump broke down and most of the plants withered away. In ’98 the plants rotted due to heavy showers. Due to this bad luck, the GIE was indebted. It couldn’t provide the working capital for the purchase of fertiliser anymore and had to stop giving advances to the farmers for the hiring in of labour. So farmers had to provide the working capital themselves. A very remarkable feature was that the yields of the members of the GIE strongly differed, whereas plot sizes and access to knowledge and infrastructure were the same for all farmers. Section three will try to explain these different yields by differences in access to labour and access to working capital.

3. The empirical results

An extensive questionnaire of 1999 provides data on a range of variables: the type and quality of the plot's soil, the labour input of household members, hired labour on the plot and on other land, fertiliser use, ownership of cattle, access to credit and to labour, the household composition, the activities and education level of the household members, transfers from emigrated household members and finally shocks to the household during the last eight years. We used the proceeds of the banana plants in 1998 as the left hand side variable (figure 3.1)[5]. The average yearly proceeds of a plot were 162 kg. This amounts to a sum of 21.918 FCFA[6].

Figure 3.1. : The banana harvest of 1998 (in kg per plot)



Source: GIE (1998)

We will now try to explain the sizeable differences in proceeds. More specifically we will test 5 hypotheses. This will allow us to analyse whether there exist are imperfections in the labour and the credit markets and if so, whether these imperfections have an impact on the financial viability of the project.

Hypothesis 1: The production decisions are independent of the consumption decision.

We will start by testing this very general hypothesis. One's rejected we will look for the causes of the rejection by testing more specific hypotheses.

In the presence of perfect markets, the neo-classical model predicts that the differences in proceeds can be explained by the differences in the production conditions, so independent of the houshold consumption decision. In this case the production conditions differ in soil type and quality. We test the null hypothesis against the alternative that other variables, like household features, also have explanatory power. We estimate[7]:

$$q_i = a + bz_i^q + gz_i^h + e_i \qquad \text{(III.1)}$$

with i = 1 … 28 the 28 farmers

q_i is the banana production per plot[8]. The vector z_i^q contains two dummies, one for the fertility of the soil and one for the humidity of the soil[9]. The vector z_i^h contains information on the household structure, the physical capital of the household and the perception of the farmers of the operation and management of the GIE. We test the null hypothesis $H_0 : g = 0$ against the alternative $H_A : g \neq 0$. We first estimate the model with only the vector z_i^q at the right hand side. Then we include the vector z_i^h. We compare both regressions using a F-test. The results can be found in table 1. We can see that in the first regression both soil dummies are statistically significant at the 5% confidence level, but an R^2 of only 23 percent indicates that the explanatory power of the model is limited. In the second regression, some of the elements of the vector z_i^h are significant and the explanatory power of the model increases to 67 percent. On the basis of an F-test we can reject the null hypothesis $H_0 : g = 0$, i.e. we reject that the neo-classical model is valid. The following hypotheses will try to find explanations for this rejection by looking more closely at the elements of the vector z_i^h.

Hypothesis 2: There exists a perfect labour market in Pata.

There is a vivid labour market in Pata. We can distinguish different forms of hired labour. First there are the permanent labourers who work the whole year and very often several years in a row on the fields of one household. Secondly, a household can hire in seasonal labourers. This happens in the period March-January and most frequently in the rainy season, June-September. Thirdly there are the so-called "navetanes". These are young men who travel in groups of 3 to 5 from village to village and look for high paying work for several days. The farmers can also ask village women to help them out. This happens in two ways. Either they ask a household for some help with for example harvesting or another urgent task. In that case one or more women from this household will help them out. Or they hire in one of the traditional "women teams" in Pata. These teams consist of 4 to 7 women. The questionnaire pointed out that the owners of a plot frequently use each of these five forms of labour. For example, at the moment of the questionnaire, August 1999, 10 of the 28 farmers employed permanent labourers, 12 farmers employed seasonal labourers, 5 farmers were working with navetanes and as much as 21 farmers were depending on help of women from other households. These figures suggest that there is a vivid labour market in Pata. Yet to the question "Do you experience problems in finding sufficient labour?", only 8 farmers responded that they never experienced troubles. Also 8 farmers responded having troubles every year while 12 responded having troubles from time to time.

For these troubles the farmers gave three reasons. (1) I can't find good labourers, (2) I don't have enough food for the labourers and (3) If I don't have good equipment, labourers don't want to work for me. The first reason is related to problems of motivation and supervision. The second and third reasons point to imperfections in the credit market, while the third reason also points out to imperfections in the market for draft animals. Which of these reasons applies to the work on the plot? The plots are small and the work consists mainly of very labour intensive activities that are easy to supervise. The farmers have access to the same equipment for the work on the plots and draft animals are of no use on the small plots. It is however plausible that the second reason is valid for the labour allocation on the plot: farmers with little liquidity cannot support permanent and temporary labourers and cannot pay the occasional navetanes and women workers. So, it seems that for some families there is a restriction on the hiring in of labourers and according to the model of subsection 1.2. whe should be able to find a connection between the labour input on the plot and the household composition.

We will now test this. The dependent variable is an aggregate of the number of women, children, men and labourers who harvested and weeded on the plot in August. The questionnaire didn't provide accurate information on the labour time, but because both weeding and harvesting have to be done in a short time period, it seems that the weighted number of persons is an acceptable proxy for the labour input on the plot[10]. On the right hand side we include some variables on the household composition (More details on the variables can be found in table I). Further we also include our two soil dummies and cattle ownership. Cattle ownership is a proxy for the available liquidities of the farmer to finance the labour input on his plot.

$$\begin{aligned} labour_i = a + b_1 soil_i + b_2 soil2_i + g_1 women15_i + g_2 men15_i \\ + g_3 women50_i + g_4 men50_i + g_5 cattle_i + e_i \end{aligned} \qquad \text{(III.2)}$$

with i = 1 … 28 the 28 farmers

If the coefficients g_1, g_2, g_3 or g_4 significantly differ from zero, we reject the null hypothesis of a perfect labour market. We find that the household variables aren’t significantly different from zero, which implies that the supply of both permanent and temporary labour is sufficiently large to enable even small families to cultivate a whole plot. Cattle ownership however is positive and significant at the 5 percent level. Cattle is used as a collateral for credit. This suggests that although the labour market is working fairly well, the labour input may not be optimal due to lack of working capital. We will now turn to a closer examination of the availability of credit.

Hypothesis 3 : There exists a perfect credit market in Pata.

In the questionnaire, 15 out of the 28 farmers said that they would be able to obtain credit from family, friends, neighbours or other persons in the village if needed. Our dependent variable, the dummy *dcredit* equals 1 for these 15 farmers. But, in a perfect credit market, every farmer should have access to credit. What variables can explain the difference in access? Firstly, the cattle ownership, *cattle,* which acts as collateral. *Cattle* is measured as continuous variable that expresses the value of the household's cattle ownership in FCFA. There are very sizeable differences in cattle ownership among the households. We find a range between 0 and 450.000 FCFA with an average of 200.000 FCFA. *Cattle* is the same variable as we used in the former regression to proxy the access to credit. Here we will be more rigorous and consider two other relevant variables. First, there is a lot of emigration out of the area to the city but also to Europe, especially to Spain and France. The emigrated family members often provide funds when they are needed for an emergency or for working capital. Therefore we also include an estimate of the amount of money that is sent by emigrated household members[11]. Secondly, I include the dummy "enterpreneurship". Farmers who are involved in a lot of activities have more informal sources of credit due to the linkages through these activities than farmers who are not involved in other activities. The dummy equals one for the enterpreneurial farmers and zero for the other farmers.

$$dcredit_i = a + g_1 cattle_i + g_2 emigration_i + g_3 enterpreneurship_i + e_i \qquad \text{(III.3)}$$

with i = 1 … 28 the 28 farmers

Table Ishows that the model predicts access to credit in 73% of the cases. Cattle ownership and "enterpreneurship" are significant at the 5% level, while immigration is significant at the 10% level. In what follows we will try to assess the importance of this imperfect access to credit for the use and allocation of labour and fertiliser.

Hypothesis 4: Hired labour and fertilizer use do not depend on access to credit.

We will test whether cattle ownership explains the input of labour and fertiliser[12]. We will do this for the month of August. This is the month when lack of working capital is strongest. Starting from the month of July until September, farmers often face financial problems. On the one hand there is a strong need for labour to weed the fields of millet, corn and peanuts. On the other hand the food stocks are often very limited or even exhausted, while the next harvest comes in only in September. In the questionnaire only 9 out of the 28 farmers reported that they never had to sell cattle in this period to meet their liquidity needs; 4 farmers had to sell catlle almost every year, while 15 farmers sold cattle only in years with a bad harvest. In a first regression we will verify if cattle ownership can explain the hiring in of labour. The dependent variable is the number of hired in labourers, *hlabour.* On the right hand side we include *cattle*, the two soil dummies and finally the labour-land ratio. It is a continuous variable that gives the share of the number of household members engaged in agricultural household production to the amount of land cultivated by the household. This ratio controls for the demand for labour of the household.

$$hlabour_i = a + b_1 soil1_i + b_2 soil2_i + g_1 cattle_i + g_2 llratio_i + e_i$$

with i = 1 … 28 the 28 farmers (III.4)

The coefficient g_1 is significantly positive at the 10 percent level. This suggests that cattle ownership has an impact on the hiring in of labour. The other coefficients have the expected sign (better soil features lead to a higher input of labour and a household with a larger labour-land ratio hires less labourers), but are not significantly different from zero.

We will now test if the liquidity constraint also influences the input of fertiliser. The dependent variable is fertiliser use on the plot. We use cattle and the two soil dummies at the right hand side. We also include the cultivated hectares of peanuts, because the Senegalese peanut company gives fertiliser in advance when one buys peanut seeds. So peanut cultivating farmers have more easy access to fertiliser. Finally we include a dummy for the use of natural fertilizer. This dummy is equal to 1 if the farmer uses much natural fertiliser (relatively to artificial fertilizer) and equals 0 if the farmer uses not quite so much. This dummy controls for substitution between the two types of fertiliser.

$$fertilizer_i = a + b_1 soil1_i + b_2 soil2_i + g_1 cattle_i + g_2 hctpeanuts_i + g_3 dfert_i + e_i \quad \text{(III.5)}$$

with i = 1 … 28 the 28 farmers

Cattle is positive and significantly different from zero at the 5 % level. So we can reject the hypothesis that access to credit has no impact on input demand. The other explanatory variables aren't significantly different from zero.

Hypothesis 5: Farmers with limited access to credit choose less risky crops.

This hypothesis corresponds to the formerly discussed risk management strategy of poor agricultural households. Because plots in the irrigation project are of fixed and equal size, we could not use the irrigated cultures for the purpose of our analysis. But, besides the plot of the irrigation project, the farmers of Pata cultivate fields of millet, maiz and peanuts. Therefore, we test if limited ex post access to credit induces farmers to allocate more land to the less risky, but low yielding millet compared to the more risky, but high yielding peanuts. The dependent variable is the fraction of land allocated to millet to land allocated to peanuts. Though not as risky and high yielding as the irrigated cultures, peanut cultivation is more risky and high yielding than millet. We include cattle as a proxy for credit access. We also control for the substitute of another risk-management strategy namely diversifying activities by working off-farm. Again we control for the labour-land ratio of the household.

$$hctmillet / hctpeanuts_i = a + g_1 cattle_i + g_2 offarm_i + g_3 llratio_i + e_i \quad \text{(III.6)}$$

with i = 1 … 28 the 28 farmers

If g_1 or g_2 are significantly negative, we suspect that the choice for millet is influenced by the ex post access to credit. Table Ishows thatt g_1 and g_2 are negative and significantly different from zero at the 10 per cent level. The labour-land ratio is significantly positive, so families with a relatively high availability of labour would cultivate more millet than peanuts. Although the cultivation of millet is more labour intensive, this is a rather surprising result , since we could not reject that the labour market works perfectly. Another explanation could be imperfections in the land market. If a large household is not able to find sufficient land for the extensive peanut culture, it will be forced to cultivate more millet; this causes a positive link between the amount of cultivated millet and the labour-land ratio. The questionnaire didn't provide information on the land market but informal talks with farmers indicated that especially the large households have difficulties in finding land near the village. So this would provide an alternative explanation for the positive coefficient of the labour-land ratio.

4. Conclusion

This paper was an attempt to discuss the impact of market imperfections in the context of a developing project. The project considered here was an irrigation project in Pata, the South of Senegal. Some of the farmers involved in the project manage to reach high yields, other farmers are indebted. The findings of the paper show that market imperfections can explain part of the differences in success between the farmers. The findings can be summerized as follows.

- There is a vivid labour market in Pata. The supply of permanent and temporary labourers enables also the small households to cultivate their plots of land. Therefore, we cannot say that the project suffers from imperfections in the labour market.

- Careful analysis of the data leads to the rejection of the hypothesis of a perfect credit market. For example, the households' access to credit depends on their cattle ownership. This has two implications for the activities in the area. (1) Firstly, households with little fysical capital can only finance a limited quantity of labour and fertiliser and have a lower yield on their plot. This endangers the overall financial viability of the project. (2) Secondly, these poor households also prefer less risky cultures. This is a well known risk-management strategy. We can agrue that the project doesn't take this strategy into consideration because the project area is divided in plots of equal size. Therefore a farmer who would wish to cultivate a smaller plot in order to reduce risk would not choose to participate in the project or would participate, but in that case with a larger than optimal plot size.

These conclusions lead to two possible policy implications: either the size of the plots should vary with the households' fysical capital or there should be a provision of credit for inputs. Although, both policy options could contribute to the financial viability of the project, I doubt whether the project could generate net revenues. The core problem of the project would seem to be the occasionnaly heavy rainfalls, technical problems with the irrigation system, the lack of storage facilities and lack of information on the market prices.

Table I

Dependent Var. / Expanatory Var.	1 (OLS) Banana production	2 (OLS) Banana production	3 (OLS) Labour input on the plot	4 (Probit) Dummy for access to credit	5 (OLS) Hired labour	6 (OLS) Fertilizer use on the plot	7 (OLS) Land for millet / land for peanuts
Soil1	29205 2.530*	70.816 3.638*	6.372 1.915**		1.004 1.225	64.322 2.126*	
Soil2	15159 2.074*	47.145 0.986	-.822 -0.401		0.392 0.741	-19.445 -1.041	
Women15-50		13.446 3.481*	.097 0.192				
Men15-50		15.166 2.848*	.203 0.382				
Women+50		31.259 1.335	-1.390 -1.179				
Men+50		46.318 -2.272*	.254 0.141				
Cattle		8.01e-06 1.652	1.54e-06 3.924*	.236e-04 2.271*	1.52e-07 1.835**	.01e-03 2.890*	-1.81e-08 -1.905**
okgie		16.527 3.364*					
emigration				.611e-02 1.685**			
enterpreneurship				9.527 1.963*			
labourland					-.467 -1.639		0.0615 0.200**
HctPeanuts						2.192 1.334	
dfert						13.472 0.531*	
offarm							-8.41e-08 -1.989**
Cons.		86.370 -2.228*	2.962 1.137	-11.213 -2.056*	1.45 2.40*	47.664 2.742**	0.276 5.556*
	R^2 = 0.2329 Adj R^2 = 0.1716	R^2 = 0.6653 Adj R^2 = 0.5244	R^2 = 0.6235 Adj R^2 = 0.4917	Pseudo R^2 = 0.7314 Log lik. = -5.1946	R^2 = 0.2515 Adj R^2 = 0.1213	R^2 = 0.5841 Adj R^2 = 0.5018	R^2 = 0.3567 Adj R^2 = 0.2762

F-test regression 1/ regression 2 = 4.22*
*significant at the 5 % level, ** significant at the 10% level

soil1 = a dummy variable that equals 1 if the quality of the plot's soil is above the average quality.
soil2 = a dummy variable that equals 1 if the humidity of the plot's soil is above the average humidity
women15-50 = a continuous variable that gives the number of women in the household who are between 15 and 50 years old
men15-50 = a continuous variable that gives the number of men in the household who are between 15 and 50 years old
women+50 = a continuous variable that gives the number of women in the household who are older than 50
men+50 = a continuous variable that gives the number of men in the household who are older than 50
cattle = a continuous variable that gives the money value of the households' cattle
okgie = a dummy variable that equals 1 if the farmer is happy about the management by the GIE
emigration = a continuous variable that estimates the money value sent by emigrated family members based on the number of migrated family members, the place they migrated to (Europe or Dakar), and the frequency and amount they sent according to the farmer.
Enterpreneurship = a dummy variable that equals one if the farmer is involved in a lot of different activities compared to the average farmer.
Labourland = a continuous variable that gives theshare of the household members engaged in agricultural household production to the amount of land cultivated by the household.
Hctpeanuts = a continuous variable that gives the cultivated hectares of peanuts
Dfert = a dummy that equals 1 one the farmer uses relatively a lot of natural fertilizer
Offarm = a continuous variable that estimates the amount of money urned offarm by the household.

Notes

[1] Based on Carter, M., R. and Wiebe, K., D. (1990)

[2] This expansion of the model is based the articles of Dercon (1996) and Carter en Wiebe (1990), which respectively model the labour and land allocation between a high risk and a low risk culture.

[3] We use a constant because we assume that all farmers are equally risk avers. However, the risk behaviour is not the same because this is being influenced by the chance of M*.

[4] The result of the empirical analysis of labour motivation show that every member of the GIE has optimal incentives to cultivate his own plot. The labour motivation for other tasks in the GIE is sub-optimal. We distinguish the poor incentives for the technical assistant, for the work on the common plot and for the maintenance of the infrastructure. These empirical results are not included in this paper.

[5] In 1998 only bananas were cultivated on the plots. The semence for the aubergine arrived too late and the hot chilli peppers rotted due to heavy rainfall.

[6] The yearly proceeds are the sum of different harvests. The harvest carries on whole the year and every two weeks a sale of bananas takes place. The price of the bananas is determined by the government and fluctuates between 130 and 140 CFA per kilo. So our assumption of exogenous prices is satisfied.

[7] Based on Udry, C. (1996).

[8] In 1998 only bananas were cultivated on the plots. The semence for the aubergine arrived too late and the hot chilli peppers rotted due to heavy rainfall. All farmers cultivated the same area of bananas.

[9] These dummies aren't based on objective measurement, but are a reflection of the farmers' own perception. Their perception was compared with the one of the technical engineer. In 8 out of ten cases the perception of the farmer was confirmed.

[10] Weights are 1 for adults, 1/3 for children and 2/3 for women and men older than 50.

[11] For this estimate we take into consideration the number of migrated family members, the place they migrated to (Europe or Dakar), and the frequency and amount they sent according to the farmer.

[12] Based on Feder, G., Lau, L., J., Lin, J., Y. and Luo, X. (1990)

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