Spillovers from globalization on land use: Evidence from Madagascar

Bart Minten (Cornell University)
Lalaina Randrianarison (WWF)
Johan Swinnen (KULeuven)

Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

Spillovers from globalization on land use:
Evidence from Madagascar

Bart Minten, Lalaina Randrianarison and Johan Swinnen[1]

Abstract

The effect of globalization on the environment and natural resource use in developing countries is hotly debated. We contribute to this debate through the analysis of primary data collected with small contract farmers in Madagascar that produce vegetables for export to Europe. Strong spillover effects of these trade opportunities on land use exist. Using a matched plot sampling design, the productivity of rice - the main domestically consumed staple - is shown to be two thirds higher on those fields that were contracted during the off-season for the production of vegetables. This increase in yields is linked to an increase of soil fertility due to the application of fertilizer and compost which farmers would not use prior to the contracts. While agricultural output goes up significantly, labor productivity stays the same, suggesting that there is greater labor absorption on existing land and the diffusion of this type of technology/contract farming at a larger scale throughout Madagascar would be expected to substantially decrease incentives to deforest by increasing wages and boosting productivity of existing lands relative to newly deforested ones.

[1] Corresponding author: BP 6317, Antananarivo 101, Madagascar; e-mail: bminten@iris.mg. The authors would like to thank the Dutch Government, the European Union and the World Bank for financing this study through the WWF project "Trade, poverty and the environment". They would like to thank participants at the start-up and review conferences of this project in Antananarivo, Den Haag and Washington DC for useful discussions on the topic.

1. Introduction

Globalization, trade liberalization and the lowering of barriers to trade has generally led to an increased inflow of foreign investments and the establishment of multinationals in developing countries. Critics argue that this type of investments cause more harm than good as they exploit the workers in developing countries and might lead to permanent environmental damage. Environmental degradation in particular could potentially be linked to mainly two factors due to globalization. First, the increase in trade might lead to higher incomes which would alter demand for environmental goods and services (Grossman and Krueger, 1995; Cropper and Griffith, 1994). Second, globalization might also lead to increasing investments in countries with lower environmental standards and the global natural resource base might end up irreversibly depleted or damaged (Reed, 2001).

While these arguments are potentially valid, they ultimately have to be tested and verified by empirical evidence. We contribute to this research by looking at a case study of the impact on land use of the contract farming for export of vegetables from developing countries. We study the effect of such contractual arrangements on land use in the case of Madagascar. We show that, using a matched pair sampling method where we control for the effect of plot and farmer characteristics, rice yields on the plots that are contracted in the off-season are two thirds higher than on regular rice plots. There are thus potentially high beneficial environmental spillovers from contract farming for exports: the existing agricultural land is more intensively used as land is cultivated in the off-season and production is higher in the main season.

This is an important finding given that land extensification and deforestation has been the norm in Madagascar as to feed a rapidly growing population. It is estimated that, over the last forty years, about 20% of the increase of agricultural production was achieved through intensification of the existing land and 80% through land extensification often at the expense of forested land (World Bank, 2003; Moser, 2004; Green and Sussman, 1990; Jarosz, 1993; Keck et al., 1994). This is even more dramatic given the unique biodiversity that is found in the forests in Madagascar (Goodman and Benstead, 2003; Kull, 2000; McConnell, 2002). The government and the donors alike have therefore been trying to devise schemes, but mostly unsuccessful or unsustainable, as to increase productivity on the existing land in cultivation. Our results seem to indicate that increasing trade might lead in some cases to the much sought-after land intensification.[2]

The structure of the paper is as follows. First, we develop a conceptual framework. Second, we explain the methodology and present the set-up of the survey that was used for primary data collection. In the third chapter, we give some background information on the farmers visited and the contractual arrangements in place for the production of vegetables. In section four, we look specifically at the issues related to rice productivity based on the declarations of the farmers themselves. Then, the econometric results are presented. We finish with the conclusions.

2. Methodology

A primary survey with 200 randomly selected contract farmers was organized during the months of June and July 2004, i.e. immediately after the rice harvest of the main season, as the main focus of the study was to measure the spillovers of contract farming on rice. We opted to select those households with ricefields as to make the measurement of spillover effects straightforward. Anecdotic evidence suggests that these spillover effects are equally well present on the uplands. However, they are more difficult to measure and quantify given the multitude of crops that are usually grown on upland plots.

A comprehensive survey was then implemented where questions were asked on the demographic situation of the household, land assets, the nature of the contract, the relationships with the firm, the benefits and disadvantages of working with contracts and perceived effects on welfare. As Malagasy farmers commonly cultivate many small plots and in order to keep data collection simple, we asked the enumerators and the farmers to

[2] However, this does not need to be the case. Minten and Méral (2005) show that an increase in trade has also led to increased deforestation, especially in the South-West of the country.

select one lowland plot with a contract with the firm and a second lowland plot without off-season crops and contracts. It was asked that, if possible, plots would be selected with similar topographic characteristics.

Detailed questions were then asked on the production levels and the production conditions of these selected plots during the rice production and the off-season cultivation periods. Because these two plots were cultivated simultaneously, we are able to correct for farmer-and plot specific effects that typically bias cross-sectional productivity analysis (Barrett et al., 2004).

For our econometric estimations we rely on the panel data literature that we adjust to study the problem at hand. For this, we build on the methodology that was recently developed by Barrett et al. (2004). As two plots are selected that are cultivated by the same farmer, fixed variables related to the community and household - which are often very difficult to measure – can be ignored and the analysis can be focused on the effect of plot specific factors. Given that we have a significant number of variables that control for potential physical differences, we are able to separate out the effect of spillovers from differences in physical characteristics.

The technologies on the two rice plots, the contracted and the regular plot, can be represented by general functional forms:

$$y_c = f(x,z) \quad (1)$$

$$y_n = g(x,z) \quad (2)$$

where the f and g subscripts reflect the technology employed. Using a Cobb-Douglas specification, this gives us:

$$\ln y_c=\alpha_{c0}+\Sigma_{i=1}{}^{r}\beta_{ci}\ln x_{ci}+\Sigma_{i=1}{}^{s}\gamma_{ci}z_{ci} \quad (3)$$

$$\ln y_n=\alpha_{n0+}\Sigma_{i=1}{}^{r}\beta_{ni}\ln x_{ni}+\Sigma_{i=1}{}^{s}\gamma_{ni}z_{ni} \quad (4)$$

where lny is the logarithm of rice output, lnx is the input application rates, and z is exogenous effects on the production of the plot.

When we stack the observations from the two different technologies and add an indicator variable, Contract, taking value one on rice plots with a contract in the off-season and zero on those rice plots cultivated without a contract, the specification can be written as:

$$\ln y=\alpha_{n0}+\Sigma_{i=1}^{r}\beta_{ni}\ln x_i+ \Sigma_{i=1}^{s}\gamma_{ni}z_{ni} +Contract[\alpha_0 + \Sigma_{i=1}^{r}\beta_i\ln x_i +\Sigma_{i=1}^{s}\gamma_i z_i] \qquad (5)$$

where α_0 captures captures the expected base productivity difference irrespective of input levels (α_{c0}-α_{n0}). We can directly estimate equation (5) using a random effects estimator. However, unobserved heterogeneity might bias the estimated coefficients of the two production functions and will therefore also bias estimates of the base and marginal productivity differentials of interest if we estimate equation (5) directly.

If individual farmers are simultaneously using both technologies, we can use the matched pairs sample – a sample of paired plots cultivated by the same farmer in the same year, one with the new contract, the other without contract in the off-season – to resolve the unobserved heterogeneity problem. If we subtract equation (4) from equation (3), we get the differential production function

$$dy = \alpha_0 +\Sigma_{i=1}^{r}\beta_i d\ln x_i+ \Sigma_{i=1}^{s}\alpha_i dz_i + d\varepsilon \qquad (6)$$

Where $d\ln y= \ln y_c-\ln y_n$ is the difference in rice output, $d\ln x=\ln x_c-\ln x_n$ reflects the difference in input application rates on the two plots, $dz=z_c-z_n$ reflects exogenous differences in the plots, $d\varepsilon = \varepsilon_c-\varepsilon_n$ is a mean zero, independent error term. All farmer-specific but plot-invariant characteristics, whether observed or unobserved, have been differenced away to remove potential sources of bias. Direct estimation of equation (6) therefore gives consistent and unbiased estimates of productivity differences attributable to the contract technology (Barrett et al., 2004).

3. Descriptive statistics of the farmers

The households interviewed have on average six members. Half of the members are less than 15 years old. 7% of the households are female-headed. The average age of the household head is 37 years. Only 1% of them did not do any studies at all. 64% of them had finished primary schools. 27% of the contractors are member of a farmers' organization. The selected household has on average 8 years of experience with contract farming.

Farm sizes of contractors are small. The average area cultivates is a little below 1 hectare, the national average (Minten et al., 2003). About one-third of the total area is the more valuable lowland used for rice cultivation. Households own 3 rice plots on average. During the agricultural season 2003-2004, farmers had on average 5 ares under contract in total over the whole year. The contracted crop was in most cases French beans. 97% of the farmers declared to have grown this crop over the last agricultural season. To a lesser extent, the contract involved gherkins (87%). Leek, peas and other crops were relatively less important.

The institutional arrangements between the firm and the farmers are set-up as micro-contracts. The written contracts are standardized with identical inputs, credit conditions and prices by product. Once a contract is signed, the farmers are then required to follow the rigid instructions of the firm. They have to labor the land in time and have to apply two card-loads of compost on the plot before the planting. Seeds, fertilizer and pesticides are distributed by the firm and have to be paid back in kind. The value of the average credit per contract is estimated at about 10,000 Ariary or 5 US dollar. This compares to an average value of produce sold under one contract of 15 US dollar.

One of the contributions of the firm is that it teaches farmers how to make compost. The compost consists of a mixture of manure and vegetable matter. Its main benefit on the fields is in maintaining the soil structure, to provide nitrogen and other minerals that promote healthy crop growth and in providing the ability of the soil to retain moisture (Jacoby et al., 2004). The use of compost is long-lasting and can have an effect on the fertility of the soil for some years and might therefore be the cause of spillover effects. The compost that the farmer makes is then combined with chemical fertilizer.

4. Rice productivity in Madagascar and qualitative evidence

Madagascar is a rice economy par excellence and rice is by far the major staple grown in the country. To start off the analysis on rice productivity of the contracting households, we rely on the perceptions of the households themselves regarding determinants of rice productivity. A question was asked on what households considered the main constraint to increased rice productivity on their lowland plots. They were asked to rank twelve types of potential constraints on a scale from 1 (not important) to 4 (very important).

The answers show the extent to which households see access to nutrients as a main constraint to improved rice productivity in the highlands of Madagascar (Table 1). 71% of the farmers gave this answer when the 'very important' and 'important' categories are combined. Access to labor is the second most important constraint and on third comes access to cattle for manure, again indicating the problem of nutrient replenishment. These results are consistent with previous studies in the highlands of Madagascar. For example, Freudenberger (1998) found in villages in the province in Fianarantsoa that farmers considered access to cattle for manure to be more important than access to land to increase their rice production. Randrianarisoa and Minten (2005) came to similar conclusions in the Vakinankaratra and Fianarantsoa region.

These results indicate to what extent contract farming might ease production constraints in rice productivity given that access to inputs is mentioned by the majority of the farmers as the main constraint to higher rice productivity. We now turn to the quantitative analysis of the spillover effects.

5. Spillovers on land use

Unconditional land productivity differences between the two types of plots are calculated. The results indicate that rice productivity is 64% higher on the plots with a contract compared to those plots without a contract and off-season crops: yields increase from 3,6 to 6,0 ton per hectare. A t-test shows that these differences are largely significant. The results are similar when production levels are corrected for those farmers that say that production was less due to cyclone Gafilo. A selection equation and the simple descriptive statistics might indicate that the simple unconditional land productivity averages might still mask some different treatments that can not be separated in simple averages. We will therefore separate these different effects using multivariate regression analysis.

As explained in the methodological section, a differential yield regression was first run to explain land productivity differences between the two plots (Table 2). In this specification, all farmer- and community-specific variables, observed or unobserved, have been differenced away to remove all type of potential bias. The marginal yield effect estimates are thus consistent in this estimate. In a second specification, the random effect model, farmers' characteristics were allowed to vary and to explain variation in the pooled yield differences. A Hausman test was run to test for the appropriateness of the two models. The results indicate that the random effect model is strongly rejected and that the differential yield specification is preferred.

The results of the differential yield regression indicate that the physical characteristics contribute little to the explanation of yield differences between the two plots as none of their coefficients turn out significant. More labor use leads to significantly higher productivity while input use in rice production has surprisingly little effect. It might be that inputs are relatively more used on those plots that suffer fertility constraints. The number of years of experience on the plot leads to significantly higher productivity. One year of extra experience increases productivity by almost 2%. The natural shocks have the expected negative effect. One extra day of flooding during the cultivation period reduces the yield by 6%. This illustrates to what extent the cyclone Gafilo might have affected rice production of the year 2004.

Turning to our variables of interest, the intercept is shown to be large and significant, indicating that there are significant rice productivity differences between contracted and non-contracted plots. The difference is estimated to be 2298 kilogram per hectare, close to the unconditional yield difference. So, the contract during the off-season improves land productivity in the main season. The effect of variation of other off-season activities was also tested. The number of years that the contract has been in place on the particular plot matters. Every extra year would increase productivity by 3%. Other off-season crops lead also to higher productivity but less so than for the years of contracts. This effect is also statistically not significant. Additional contracts that were fulfilled on top of the one that is accounted for in the base increase, lead to an increase of 12% of the production of rice yields for every extra contract. T-values are highly significant. Other off-season crops do not have that same effect as its coefficient is not significant. Our results indicate thus that the strict input and fertilization requirements by the firm lead to strong spillovers on rice production.

We test for the robustness of these spillover results by using the 'corrected' yield, i.e. the yield that farmers would have expected if there would not have been a cyclone. The results are mostly consistent with the previous analysis. The base productivity gain increases a little bit, to 3137 kg/ha. Most of the other results show significance of the same variables and the coefficients are of similar magnitudes.

Finally, we did an Oaxaca-Binder decomposition to explain the driving forces for the differences in yields between the two plots. We differentiate between unconditional productivity gains, marginal yield gains due to changes in input and labor use and differences explained by plot-specific characteristics. The results indicate that most of the difference is explained by a base productivity effect. 92% and 95% of the difference in yield between the contracted and the non-contracted plots for the observed and the corrected yield respectively is explained by a change in intercept. Little is explained by a change in inputs, additional off-season activities and plot-specific characteristics.

6. Conclusions

The effect of globalization on the environment and natural resource use in developing countries is hotly debated. We contribute to this debate through the analysis of primary data collected from small contract farmers in Madagascar that produce vegetables for export to Europe. Strong spillover effects of these trade opportunities on land use exist. Using a matched plot design, the productivity of rice, the main domestically consumed staple, is shown to increase by 67% on those fields that were contracted during the off-season for the production of vegetables. This increase in yields seems especially linked to an increase of soil fertility due to the application of compost which most farmers would not use prior to the contracts. These results are corroborated by qualitative statements of farmers who indicated that maintaining soil fertility was a major constraint to improved rice productivity. The nutrient constraint might thus be alleviated by the trade opportunities.

As contract farming, due to increased globalization and the larger emphasis on quality and safety issues, will become more important in the future, and this especially so in developing countries, this theme should be fertile ground for further research as to better help guide policy. Further research could look at why this type of investment for the production of agricultural produce for exports is still rare in Madagascar, or Africa for that matter, the comparison of the reasons for the success of this type of contract compared to those that failed, to what extent the technology transfer of the production of compost is sustainable, the effect of the contracts on welfare, and the spillover effects of this technology on non-contract farmers in the same or neighboring villages.

References

Barrett, C.B., Moser, C.M., Barison, J., McHugh, O.V. (2004), Better Technology, Better Plots or Better Farmers ? Identifying Changes in Productivity and Risk Among Malagasy Rice Farmers, *American Journal of Agricultural Economics*, 86(4), pp. 869-888

Cropper, M., Griffith, C. (1994), The Interaction of Population Growth and Environmental Quality, American Economic Review, vol. 84, no. 2, pp. 250-254

Freudenberger, K. (1998), Livelihoods without Livestock: A study of Community and Household Resource Management in the Village of Andaladranovao, LDI, Madagascar

Goodman, S.M., Benstead, J.P. (2003), The Natural History of Madagascar, University of Chicago Press

Green, G., and Sussman, R. (1990), “Deforestation History of the Eastern Rain Forests of Madagascar from Satellite Images.” *Science* 248: 212-215.

Grossman, G., Krueger, A. (1995), Economic Growth and the Environment, Quarterly Journal of Economics, Vol. 110, pp. 353-377.

Jacoby, H.G., Mancuri, G. (2004), The (in)efficiency of share tenancy revisited: Evidence from Pakistan, mimeo.

Jarosz, L. (1993), “Defining and explaining tropical deforestation: shifting cultivation and population growth in colonial Madagascar (1896-1940).” *Economic Geography* 69:366- 379.

Keck, A., Sharma, N.P., Feder, G. (1994), Population Growth, Shifting Cultivation and Unsustainable Agricultural Development: A Case Study in Madagascar, World Bank Discussion Papers, Africa Technical Department Series 234, World Bank

Kull, C. (2000), “Deforestation, Erosion, and Fire: Degradation Myths in the Environmental History of Madagascar.” *Environment and History* 6:423-450.

McConnell, W. (2002), “Emerald Isle or Paradise Lost?” *Environment* (October) 12-21.

Minten, B., Méral, P. (2005), International trade and environmental degradation: A case study of the loss of spiny forest in Madagascar, mimeo.

Minten, B., L. Randrianarison and C. Randrianarisoa (2003), Agriculture, Pauvreté rurale et politiques économiques à Madagascar, Antananarivo: Cornell University/FOFIFA/INSTAT.

Moser, C. (2004), Causes and Misconceptions: Population, Roads, Poverty, and Deforestation in Madagascar, Cornell University, mimeo

Randrianarisoa, C., Minten, B. (2005), Getting the Inputs Right for Improved Agricultural Productivity in Madagascar: Which Inputs Matter and Are the Poor Different?, World Bank, mimeo

Reed, D. (2001), Poverty is Not a Number, the Environment is Not a Butterfly, WWP-MPO, Washington D.C.

World Bank (2003), Review of agricultural and environmental sector

Table 1: Ranking of the importance of specific constraints on rice productivity

	Ranking Importance				
Constraint	Not	A bit	Rather	Very	Total
Insecure property rights	78	12	8	2	100
Access to cattle for labor	27	36	15	22	100
Access to cattle for manure	17	21	27	35	100
Access to labor	5	25	34	36	100
Access to agricultural equipment	11	32	18	39	100
Access to agricultural inputs (fertilizer)	7	22	27	44	100
Access to better irrigation	23	32	12	33	100
Access to extension	10	31	27	31	100
Access to credit	10	35	26	29	100
Opportunities to sell	27	41	21	11	100
Storage	67	29	3	1	100
Avoid silt	71	16	3	10	100
Avoid losses due to plant diseases	62	19	9	10	100
Avoid floods	71	13	5	11	100
Avoid droughts	71	13	5	11	100

Source: Farmer survey, 2004

Table 2: Production functions for rice yields on contracted and non-contracted plot

		Dep. var. = log (yield) in kg/ha				Dep. var. = corrected log (yield) in kg/ha#			
		Differential yield		Random effect*		Differential yield		Random effect*	
Variable	Unit	Coefficient	t-value	Coefficient	z-value	Coefficient	t-value	Coefficient	z-value
intercept		7.741	**32.260**	7.244	**18.460**	8.051	**42.410**	7.157	**21.090**
Input use during rice cultivation									
labor use per ha during the main season	log(number)	0.128	**4.890**	0.146	**7.390**	0.105	**5.080**	0.118	**7.230**
input use per ha during the main season	log(Ariary+1)	-0.018	-1.190	-0.010	-1.200	-0.002	-0.140	-0.002	-0.330
Shocks and experience									
experience with the plot	years	0.016	**2.370**	0.005	1.440	0.008	1.560	0.003	0.980
problems with drought	days	-0.006	**-1.760**	-0.008	**-3.070**	-0.002	-0.680	-0.002	-0.910
problems with flooding	days	-0.059	**-2.680**	-0.056	**-3.290**	-0.023	-1.330	-0.018	-1.310
Off-season activities									
contract farming on this plot	years	0.031	**1.720**	0.004	0.290	0.035	**2.430**	0.010	0.860
off-season cropping on this plot	years	0.007	0.690	0.015	**1.840**	0.013	**1.670**	0.016	**2.450**
no of contracts this ag. season	number	0.120	**3.030**	0.094	**3.210**	0.079	**2.530**	0.083	**3.380**
non-contracted off-season crops this ag. season	number	-0.013	-0.170	0.095	**1.820**	0.037	0.610	0.080	**1.840**
Physical characteristics plot									
irrigation with a dam	yes=1	-0.029	-0.290	0.095	**1.810**	-0.070	-0.900	0.089	**2.000**
black soil	yes=1	-0.037	-0.990	-0.018	-0.670	-0.038	-1.300	-0.017	-0.750
argilic texture	yes=1	0.060	1.030	0.008	0.220	0.062	1.330	0.019	0.620
Household effects									
age	years			0.003	0.150			0.018	1.110
age squared	years*2			0.000	-0.060			0.000	-1.130
gender head of household	male=1			0.102	1.650			0.090	**1.680**
level of education	years			0.024	**1.960**			0.016	1.520
size of household	number			0.003	0.210			-0.002	-0.190
sigma_u		0.400		0.164		0.372		0.171	
sigma_e		0.416		0.416		0.329		0.329	
rho		0.481		0.134		0.561		0.213	
Hausman test									
chi2(12)		54.140				170.980			
Prob>chi2		0.000				0.000			

*: village dummies included but not reported

#: In 2004, the cyclone Gafilo hit in the Highlands of Madagascar; for those farmers that were affected, it was asked how their yield would have been, given the same inputs, without this cyclone