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One cow per poor family: effects on the growth of consumption and crop production

Aristide Maniriho[1], Mikaela Backman[2], Lina Bjerke[2] and Pia Nilsson[2]

[1] School of Economics, University of Rwanda, Kigali, Rwanda
Email: manirihoaristide1@gmail.com

[2] Jönköping University, Jönköping, Sweden
Emails: pia.nilsson@ju.se, Mikaela.Backman@ju.se, Lina.Bjerke@ju.se

Abstract

This study estimates the effects of the one cow policy on the growth of consumption and crop production in Rwanda using a random sample of households observed in 2010 and 2014. A first-difference model that takes into account the selection bias and placement effect associated with the policy and heterogeneity across households is estimated. Findings show that receiving a cow has a positive effect on crop production, indicating that the cattle has enabled households to become more productive on the farm. Findings also point to the importance of households' asset endowments and their knowledge and experience of rearing livestock for the outcome of program participation.

Keywords: Girinka; consumption; crop production; CEM; Rwanda.
JEL codes: R12; R20; O12

1. Introduction

Improving the productivity of the agricultural sector is traditionally seen as one of the most important means of poverty alleviation in developing countries (Johnston & Mellor, 1961). This follows the evidence that there are backward and forward linkages between the productivity of the agricultural sector and other sectors of the economy (Jalan & Ravallion, 2002; Haggblade, Hazell & Reardon, 2010). It is also a fact that most poor households live in rural areas and are dependent on agriculture. They often

combine small scale food cropping and livestock with a diverse set of agricultural related activities. This is particularly evident in Rwanda where more than 80 percent of the population live in rural areas with agriculture as their primary source of income and where rural poverty is almost three times as high as urban, 44 percent versus 16 percent (NISR, 2016). Hence, poverty and living standards of rural households in Rwanda, as in most of sub-Sahara, are strongly related to agricultural asset, such as land and livestock holdings (Abdulai & CroleRees, 2001).

With the intent to reduce poverty the government of Rwanda have introduced the social protection programme 'One cow per poor family program', also referred to as Girinka. This is a program that distribute dairy cows with the overall goal to reduce malnutrition and provide a source of fertilizers and additional income for the most marginalized households (IMF, 2008). Since its introduction in 2006, Girinka has distributed around 300 thousand dairy cows, with a goal to reach more than 350 thousand households by the end of 2017 (Republic of Rwanda, 2015). Other developing countries have introduced policy programs, alike the Girinka, to increase livestock ownership among poor households with poverty alleviation as the overall goal.[1]

Despite the significant amount of public resources allocated through the Girinka program, the evidence of its economic impact is still scarce, particularly its ability to improve the well-being of poor households. Klapwijk et al. (2014), study the 'One cow per family' program in Rwanda, and show that poor households are unable to provide sufficient fodder to feed a cow. They suggest that a shift to animals that require less fodder, such as goats, would better target the poor and improve the effectiveness of the program. Argent, Augsburg and Rasul, (2014), show that the transfer of livestock assets through Girinka has a positive impact on milk production and other indicators of household wealth. Particularly of those households that are also offered training on how to utilize the livestock. There are also studies that address the role of livestock assets for poverty alleviation and households risk minimizing strategies in the context of developing countries (Fafchamps, Udry & Czukas, 1998; Hoogeveen 2002; Kazianga & Udry 2006). This study contributes to the knowledge of policy induced livestock transfer by focusing on the Girinka program and its effects on household consumption and crop production. The main focus is on heterogenous treatment effects which is an

[1] For example, the 'Chickens for poverty alleviation' program in Eastern Uganda and the promotion of dairy cattle and dairy goats among smallholder farmers in Malawi and the 'Pigs for Peace' program in Kongo.

attempt to examine if there are outcome differences of program participation depending on household characteristics. Having access to data that track households over time enables us to unravel whether such effects exist while considering time-invariant unobservables. We also estimate if the results are sensitive to natural conditions. Besides topography and climate variability across Rwanda, the strong heterogeneity in soil fertility may influence fodder production and households' ability to reproduce livestock (Byiringiro & Reardon, 1996).

Assessing the impact of policies on welfare indicators is challenging from a methodological point of view. Better skilled individuals are more likely to participate in welfare enhancing governmental programs, which increases the risk of a skill bias. It is also difficult to interpret the effect of the 'One cow policy' as it is not randomly dispersed, but targeted to poor households with the risk of a placement bias. Our approach is to apply first difference estimations and the recently developed Coarsened Exact Matching (CEM) method to estimate control households to the cow receiving households (Iacus, King & Porro, 2009; 2011; 2012). Using the CEM matching technique we are able to reduce the heterogeneity in the distribution of covariates in the treated and control groups by a magnitude of four. With access to representative household-level data across Rwanda, through the integrated household living conditions survey (EICV) of 2010 and 2014, the study estimates the average treatment effect on treated. This means a comparison of the outcome between households that received a dairy cow between 2010 and 2014 and similar households that never received a dairy cow through the program. Unlike Klapwijk et al. (2014) and Argent et al. (2014), we attempt to model the selection bias and placement effect associated with the policy and explore the causal link between policy induced transfer of cattle and indicators of household wealth.

Our approach is useful from a methodological as well as a policy perspective. It applies a new matching technique to handle selection bias and can thereby provide new evidence on the heterogeneous effects associated with policy induced livestock transfer. Findings show that the Girinka program has a positive effect on crop production, indicating that the livestock has enabled households to become more productive on the farm. Findings also show that the effect on consumption depend importantly on households' ownership of agricultural assets (land and livestock) and hence their knowledge and experience of rearing livestock. These results point to the importance of wealth and learning effects for the outcome of receiving a dairy cow for household

wealth. Results also indicate that the program may not be able to target households that lack sufficient resources and experiences to make productive use of the cow.

2 Background

The overall purpose of the 'One cow policy' is to reduce poverty and assist poor households to improve their well-being through income generation. The policy was implemented in November 2006, as a part of the Rwandan vision 2020 to move from a low-income country to a middle-income country (Republic of Rwanda, 2000). The program logic is that one poor household receive a cow and, as a refund to the government, they give their first calf to their neighbor, whereas the subsequent calves are kept. In Rwanda, livestock is considered a key factor in poverty reduction. Cows in particular have an important value in the Rwanda culture as they are signals of wealth, prestige and social status (Kimenyi, 1978). The giving and receiving of a cow in the Rwandan cultural is also attached with strong value and meaning (Gravel, 1967). Thus, there is a strong cultural factor embedded in the Girinka program. To be relevant for the program, the household needs some land and some shed for the animal. This means that the very most poor and vulnerable households cannot enter the program since they often lack access to such resources. The selection of Girinka beneficiaries is conducted at the local level and each village together decide which households should be selected. Besides being part of the village, the following criteria are used to assess eligibility:

- The beneficiary has no cow already.
- The beneficiary has a constructed cows shed.
- The beneficiary has at least between 0.25-0.75 hectares of land, some must be planted with fodder (those who do not have enough land may join with others in the community).
- The beneficiary is considered as poor by the community and have no other source of income.

2.1 The role of livestock in poverty reduction

Livestock play an important role for agricultural households in developing countries because it can act as a buffer for consumption smoothing against income risk and as a generator of income. Hayami and Ruttan, (1970), inter alia, have developed a framework for the role of agricultural asset endowments as sources of agricultural

productivity in developing countries. They show that land and livestock represent a form of capital accumulation embodying inputs supplied primarily by the agricultural sector. Studies have also addressed the role of livestock and other agricultural assets holdings under conditions of income uncertainty and high risk and uncertainty linked to changes in external conditions (Rosenzweig & Binswanger, 1993; Hoogeveen, 2001). One hypothesis is that, in the absence of functioning credit markets, households that are sufficiently risk averse will save for the future to smooth consumption. In this view, livestock is a form of saving which can lead to increased future consumption and to reduced uncertainty in future consumption. Studies on the role of livestock transfers to reduce risk in low-income, high-risk environments and related issues can be found in McPeak (2006), Kazianga and Udry, (2006) and Andersson, Mekonnen and Stage (2011). Households can, for instance, sell parts of the livestock sourced food to obtain additional income. It is also possible that livestock spurs entry into nonfarm income generating activities and entrepreneurship as it can be used as collateral for loans (Reardon et al., 2000).

The fact that livestock has a dual role, as a type of saving that increases future consumption possibilities, and as a productive resource on the farm, makes such assets an important target of policies aimed to reduce poverty among agricultural households. The Girinka program in Rwanda is one example of such a policy program, targeted to poor households that lack other means to improve their well-being.

3 Model and methods

The empirical approach to assess the effects of receiving a cow on household income and agricultural production is to use household data from the two latest rounds of the Integrated Household Living Conditions survey (EICV). This is a nationwide household survey conducted by the National Institute of Statistics in Rwanda (NISR) that include welfare indicators of a random sample of around 14 400 households across Rwanda, with several efforts made to ensure representativeness through stratification and weighting. The most recent EICV survey of 2013-2014 (EICV4) is combined with the earlier survey of 2010-2011 (EICV3) and only those households that where visited in both rounds are included in the dataset. Hence, the data used for the empirical analysis is a balanced panel of 3840 observations and the sample of the 1920 panel households are selected to be representative at the national and urban/rural levels and households

that relocated, or split were tracked to obtain current information for the corresponding household members.[2] Having access to a sample of households observed in two points in time, our baseline equation is:

$$y_{it} = \lambda_0 + \gamma_0 d2_t + \lambda_1 T_{it} + Z_i + \varepsilon_{it} \quad (1)$$

, where y_{it} denote the dependent variable of household (consumption and crop production) i at time $t = 1, 2,$ (corresponding to years 2010 and 2014, respectively), Z_i denote fixed characteristics of the household, and T_{it} denote program participation. Moreover, $d2_t$ denote a time dummy and $Z_i + \varepsilon_{it}$ is the composite error term. Following the first-difference approach to handle correlated unobserved heterogeneity, the two-period data can be expressed as (Liker, Augustyniak & Duncan, 1985):

$$y_{i2} = (\lambda_0 + \gamma_0) + \lambda_1 \mathrm{T}_{i2} + Z_i + \varepsilon_{i2} \quad \forall \quad t = 2 \quad (2)$$

$$y_{i1} = \lambda_0 + \lambda_1 \mathrm{T}_{i1} + Z_i + \varepsilon_{i1} \quad \forall \quad t = 1 \quad (3)$$

First-differencing yields:

$$(y_{i2} - y_{i1}) = \gamma_0 + \lambda_1 (\mathrm{T}_{i2} - T_{i1}) + (\varepsilon_{i2} - \varepsilon_{i1}) \quad (4)$$

$$\Delta y_{i2} = \gamma_0 + \lambda_1 \Delta \mathrm{T}_{i2} + \Delta \varepsilon_{i2} \quad (5)$$

, where the unobserved fixed effect Z_i is differenced away and assumed uncorrelated with the observed variable $E(Z_i G_{i2} = 0)$, and where T_{i2} is the treatment dummy that indicate program participation of household i at time $t = 2014$. Specifically, the treatment dummy takes the value one if the household has received a cow between 2010-2014, but not in 2010, and zero if the household never received a cow through Girinka. Should there be any selection bias resulting from factors that are time-invariant, the formulation of equation (5) should address this (Hsiao, Pesaran & Tahmiscioglu, 2002).

Additional factors could violate the assumption of strict exogeneity, for example if the assignment of livestock through the program is not random, but targeted to specific households. As discussed, the distribution of dairy cows through Girinka is coupled with eligibility conditions and targets poor households. Should this not be accounted for, the estimated effect of program participation will be biased. Hence, the desired effect is the counterfactual mean difference in the outcome variables i.e., the average

[2] See NISR (2016), p.6 for a detailed description of the construction of the panel from EICV3 and EICV4.

treatment effect on treated.[3] But, the counterfactual outcome cannot be directly observed using observational data and simple mean value comparisons between the treated and non-treated yields biased estimates. Our approach to handle this is to estimate a control group with distributional characteristics as similar as possible to the treated households. The approach in this paper follows Nilsson (2017), who uses the CEM method rather than propensity score matching (PSM). Following Iacus et al. (2011; 2012), the main justification for CEM is that it allows the balance between the treatment and the control group to be chosen ex-ante rather than being revealed through an iterative process of ex-post balance checking. This matching procedure guarantees that adjusting the imbalance on one variable has no effect on the balance of other covariates. And since the matching is done before the regression analysis, it reduces the degree of model dependence (Ho et al., 2007).

To improve the balance between treatment and control group the CEM approach is to temporarily and ex-ante coarsen each pre-treatment covariate used in the matching. Then match on the coarsened data and use the uncoarsened values of the matched units in the subsequent regression analysis. The matching procedure generates the following weights:

$$w_i = \begin{cases} 1, if\ T_i = 1 \\ 0,\ if\ T_i = 0\ and\ i \in M_2^A for\ all\ A, \\ \frac{m_1^A}{m_2^A}\frac{m_2}{m_1}, if\ T_i = 0\ and\ i \in M_2^A\ for\ one\ A. \end{cases} \quad (6)$$

, where $T_i = 1$ and $T_i = 0$ indicate the treated and untreated units respectively and A denote the subset of pre-treatment covariates used in the matching. Moreover, m_1^A and m_2^A denote the number of treated units per strata and M_2^A denote all the matched observations for the treatment level $T_i = 0$ within stratum A. Iacus et al. (2012) show that including the weights in the subsequent regression analysis is equivalent to a difference-in-difference and yields an unbiased estimate of the average treatment effect on treated. Since there will naturally remain imbalance even after the matching, as it is impossible to fully account for heterogeneity between the groups, including household and locational controls in the regression model account for the remaining heterogeneity. The following model is estimated:

[3] This can be formally expressed as: $ATT = E(y_1 - y_0|\boldsymbol{X}, T = 1) = E(y_1|\boldsymbol{X}, T = 1) - E(y_0|\boldsymbol{X}, T = 1)$. Where $E(\cdot)$ denotes the expectation operator, $\boldsymbol{X}$ is a vector of relevant control variables, and $T = 1$ indicates participation in Girinka. Further, y_1 denotes the outcome for a household in case it received a cow, and y_0 denotes the outcome for the same household in case it did not receive a cow.

$$\Delta y'_{i2} = \gamma'_0 + \lambda_1 \Delta T'_{i2} + \lambda_{i2} \Delta \boldsymbol{X}'_{i2} + \Delta \varepsilon'_{i2} \quad (7)$$

, where y_{i2} denote the dependent variable of household i, T_{i2} denote program participation and $\boldsymbol{X}_{i2}$ is a vector of household and locational controls. Moreover, the asterisk denote that the variable is weighted using the pre-estimated CEM weighs defined in equation 6.

3.1 Dependent variables

Two dependent variables are in focus, one related to household consumption and the other related to household agricultural production. Previous literature show that consumption and crop production are key indicators of wealth and food security among households in the context of developing countries (Dercon et al. 2009; Islam & Maitra, 2012). Household consumption are measured as expenditures adjusted for spatial and temporal differences in the cost of living. Consumption expenditure as a measure of household wealth is a better alternative than household incomes since income tend to vary more than consumption (Cutler & Katz, 1991). Current income is typically vulnerable to temporary fluctuations related to factors such as layoffs or family status. Also, incomes tend to underestimate the material wealth, especially in developing countries (Deaton & Zaidi, 2002). Following this, current consumption is a more reliable measure to capture changes in household wealth as long as it is adjusted for changes in the cost of living (Jalan & Ravallion, 2002; Meyer & Sullivan, 2003).[4]

The second dependent variable is crop production, defined as total real value of households per hectare crop production, following previous studies (McMillan, Whalley, & Zhu, 1989; Alston, Beddow, & Pardey, 2009). The variable is included to assess if receiving a cow results in higher crop yields and improved agricultural productivity. A total of 122 household in the sample where granted a dairy cow through the Girinka program between 2010-2014, of which 45 percent are in the Eastern province, 28 percent in Southern province, 19 percent in the Northern province, and 8 percent in the capital province Kigali City. While the number of households in the sample that participate in Girinka may seem small, it corresponds to almost eight

[4] The questionnaires remained essentially the same in the two surveys and the calculation of household consumption is consistent and with respect to subgroup (depending on poverty), time, and the place of residence (urban/rural) (NISR, 2016).

percent of the households, which can be compared to the national average which is around 1.5 percent (in 2015).

3.3 Coarsened exact matching

In choosing the pretreatment variables we consider the criteria used to select households into the Girinka program, discussed in section 2.1. The variables used to estimate control households are presented in table 1 and results from estimating two CEM estimations are presented in table 2. The first match variable is a proxy for poverty using annual consumption expenditure and the categories extremely poor, poor and non-poor (NISR, 2016). This variable is constructed to consider that the poorest and the non-poor households are not targeted by the program. Households' ownership of land and cattle considers that some land is required to provide fodder for the cow and that no cows can be owned to become eligible. Since the CEM produces an exact match on all pre-treatment covariates, control households do not own cattle. Households ownership of or access to pasture is included to further account for the ability to provide fodder and location is included to account for similarities linked to location by province.

Results from the CEM estimations, including location, land and poverty shows that the matching reduces the imbalance between the treated and control group. The overall imbalance is indicated by the $L1$ statistic in table 2 (column 2). The L_1 statistic is 0.898 before the match and 0.187 after the match indicating that the heterogeneity between the groups is four times higher before the match compared to after. The difference in mean of household ownership of land is one hectare before the match and almost zero after (5.6e+0.5). Adding cattle and pasture to the CEM does not reduce the heterogeneity between the groups, reflecting that ownership of land captures the heterogeneity linked to livestock and pasture.

Table 2. Results of the Coarsened Exact Matching

	L1	Mean difference	25 %	50 %	75 %
Algorithm 1[a]					
Poverty	0.004	0.002	0	0	0
Land	0.063	5.6e+05	0	0	6.2e+05
Province	0.064	0.064	0	0	0
L1 (Pre-match imbalance) test[c]	0.898				
Multivariate L1 distance (post-match): 0.187					
Algorithm 2[b]					
Province	0.065	0.065	0	0	0
Poverty	0.004	0.002	0	0	0
Income	0.054	-4.9e+05	-0.041	-0.090	0.432
Land	0.097	0.178	0	0	0
Livestock	0.196	0.797	0	1	1
L1 (Pre-match imbalance) test[c]	0.884				
Multivariate L1 distance (post-match): 0.754					

Note: Using the scott break method for imbalance.

[a] Number of strata=9, number of matched strata=8.

[b] Number of strata=28, number of matched strata=8.

[c] Perfect balance is indicated by L1=0, and larger values indicate more imbalance with a maximum L1=1 which imply complete imbalance (heterogeneity) between the groups (Iacus et al., 2011).

4 Regression results

Results using per capita consumption and per hectare crop production as dependent variables are reported in table 3 in three model specifications. Results reported in the first column are included for comparison and show the results from estimating a naïve model excluding the pre-estimated CEM weights. Results from simple mean value comparison indicate a significant and negative association between program participation and consumption growth. The subsequent column in table 3 reports the results from the estimation that include the weights, equation 7, with per capita consumption as the dependent variable. Including the weights, the treatment effect is indicated to be positive, but not significantly different from zero. This difference in results could indicate that the estimated effect of program participation is biased when the treated households are compared to all other households that did not receive a cow.
Simple mean value comparisons capture the effect of features that are linked to the assignment of the dairy cow i.e., that the policy targets poor households that have a lower level of consumption. Therefore, the coefficient reported in the first column can only be a correlation, and the coefficient of the weighted estimations in the second column accounts for selection and is therefore more reliable for policy impact analysis.

4.1 Effects of the 'One cow per poor family' policy

Results from simple mean value comparison show a significant and negative correlation between program participation and household consumption. These results are different compared to those obtained by estimating the model with the weights. Including the weights, the treatment effect is indicated to be positive, but not significantly different from zero. This could indicate that the estimated effect of program participation is biased when the treated households are compared to all other households that did not receive a cow. Possibly because the effect captures features that are linked to the assignment of the Girinka i.e., that the policy targets households that have a lower level of consumption and other indicators of economic wealth, discussed above. Therefore, the coefficient reported in the first column can only be a correlation, and the coefficient of the weighted estimations in the remaining columns reflects a causal effect, which is more reliable for policy impact analysis.

Table 3. Effect of program participation on household consumption and crop production

	log of per capita consumption		*log of per hectare crop production*
Variable	FD Coef. (Std.Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)
Girinka	-0.08* (0.023)	0.07 (0.07)	0.78* (0.21)
Household and locational controls			
Size	-0.52* (0.02)	-0.50* (0.02)	0.62* (0.11)
Age	-0.04 (0.03)	-0.06* (0.03)	0.45* (0.17)
Gender (1=female)	-0.16* (0.02)	-0.09* (0.03)	0.29* (0.13)
Higher education	0.95* (0.07)	0.93* (0.09)	-2.50* (0.50)
Savings	0.04* (0.002)	0.04* (0.002)	-0.03* (0.01)
Credit	0.01* (0.002)	0.01* (0.002)	0.02 (0.01)
Remittances	0.01* (0.002)	0.01* (0.002)	0.01 (0.01)
Internet access	0.84* (0.09)	1.20* (0.13)	-1.63* (0.65)
Land	0.07* (0.01)	0.02* (0.001)	1.63* (0.08)
Livestock	0.04* (0.01)	0.05* (0.01)	0.44* (0.04)
Fertilizers	0.01* (0.002)	0.01* (0.003)	0.16* (0.01)
Distance road	-0.007* (0.001)	-0.007* (0.001)	0.00 (0.01)
Industrial diversity	0.82* (0.10)	1.00* (0.12)	-0.74 (0.52)
Province	Yes	Yes	Yes
District	No	No	No
Constant	12.32* (0.13)	12.17* (0.16)	5.58* (0.74)
w_i	No	Yes	Yes
Matching algorithm	-	1	1
R square	0.49	0.51	0.63
Obs.	3782	3782	3777

* Indicate significance at the five per cent level or lower. Heteroscedasticity consistent standard errors in the parentheses. Independent variables measured on a continuous scale are log transformed.

Findings show that receiving a cow has a positive effect on crop production, indicating that the livestock has enabled households to become more productive on the farm. Livestock is a productive asset that can assist farmers in their cropping activities and supply manure and soil nutrients, which can be used as cost-effective fertilizers (Kato et al., 2011). The estimated effect could be reflective of improved access to organic manure and soil nutrition, which has improved the quality of the soil and enabled Girinka participating households to increase their per hectare yield. Findings show that receiving a cow has no significant effect on household consumption. As discussed, consumption expenditure is used in this study as a proxy for income and is a broader measure of household wealth compared to crop production, which is reflective of households' agricultural activities and not their overall wealth. One issue is that there may be omitted geographical factors that influence households' capacity to produce fodder and reproduce livestock. These can be linked to climate variability, soil fertility, topography and other factors that increases the risk of soil erosion (Helgeson et al., 2012). The adoption of improved water management (irrigation) and efforts to soil conservation (protection against erosion) tend to be coupled with district belonging in Rwanda (Clay et al., 1998). There can also be placement effects i.e., if the assignment of agricultural programs is not randomly dispersed, but concentrated to locations with better agricultural potential. Based on what has emerged from the previous literature, it seems like subsidized inputs are provided in greater supply to those districts that have better agricultural prerequisites (Nilsson, 2017b). To address if unobserved correlations linked to economic, political or environmental factors, influences the results, the model (equation 7) is estimated with the cluster-robust option using districts. These results are presented in column C and E and show no difference to the main results.

Including interaction effects between Girinka participation and households' agricultural asset endowments (ownership of land and livestock) gives a more detailed picture. In particular, households that own a lot of land and other types of livestock (goats and smaller rudiments) are indicated to be positively affected by participating in the Girinka program. These results can be reflective of a wealth effect, indicating that households that own land and livestock are generally wealthier and better able to feed and care for the cow. This is in line with the findings in Klapwijk et al. (2014), and the argument that the Girinka program may not benefit the poorest households as they are unable to provide enough fodder for the cow. Results could also be reflective of scale economies and learning effects. In particular, that households with knowledge and

experience of rearing livestock are better able to utilize the cow as a productive resource. Similar arguments can be made to explain the positive interaction between land and Girinka participation. Having access to an additional unit of land makes it easier to support one more livestock, the marginal cost of the extra livestock is smaller while the marginal benefit is large. These results point to positive effects associated with Girinka. They also point to the importance of knowledge and experience of rearing livestock for the outcome of the program. It seems like receiving a cow is positive for crop productivity (manure, soil nutrition effect), but it is not enough to increase the overall wealth of the poorest Girinka recipients.

Table 4. Effect of program participation on household consumption and crop production. Cluster robust estimations.

	log of per capita consumption	*log of per hectare crop production*
Variable	FD-CEM Cluster Coef. (Std. Err.)	FD-CEM Cluster Coef. (Std. Err.)
Girinka	0.08 (0.07)	0.85* (0.21)
Household and locational controls		
Size	-0.50* (0.03)	0.63* (0.11)
Age	-0.06* (0.04)	0.44* (0.17)
Gender (1=female)	-0.09* (0.03)	0.30* (0.13)
Higher education	0.93* (0.09)	-2.52* (0.49)
Savings	0.03* (0.002)	-0.03* (0.008)
Credit	0.01* (0.002)	0.01 (0.01)
Remittances	0.01* (0.003)	0.00 (0.01)
Internet access	1.20* (0.14)	-1.59* (0.65)
Land	0.02* (0.001)	1.62* (0.08)
Livestock	0.05* (0.01)	0.44* (0.11)
Fertilizers	0.01* (0.003)	0.16* (0.01)
Distance road	-0.007*	0.001

	(0.001)	(0.004)
Industrial diversity	-	-
Province	No	No
District	Yes	Yes
Constant	12.19* (0.16)	5.33* (0.75)
w_i	Yes	Yes
Matching algorithm	1	1
R square	0.48	0.63
Obs.	3782	3777

* Indicate significance at the five per cent level or lower. Cluster robust standard errors in parentheses. Independent variables measured on continuous scale are log transformed.

Table 5. Effect of programme participation on household consumption and crop production. Summary of main results.

	log of per capita consumption		*log of per hectare crop production*	
Variable	FD-CEM Coef. (Std.Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)
Girinka	0.13 (0.15)	0.06 (0.10)	0.71* (0.11)	0.71* (0.12)
Girinka×land	0.03* (0.001)	-	0.03 (0.03)	-
Girinka×livestock	-	0.01* (0.001)	-	0.02* (0.001)
Household and locational controls	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes
Constant	12.17* (0.16)	12.17* (0.16)	5.50* (0.74)	5.50* (0.74)
w_i	Yes	Yes	Yes	Yes
Matching algorithm	1	1	1	1
R square	0.47	0.48	0.63	0.63
Obs.	3782	3782	3777	3777

* Indicate significance at the five per cent level or lower. Heteroscedasticity consistent standard errors in the parentheses. Independent variables measured on a continuous scale are log transformed.

4.1 Control variables

Turning to the household-level controls. Higher education is important and households with more asset endowments have higher consumption growth. These results are broadly consistent with previous findings on the importance of pull factors, such as education, especially above primary schooling for poverty reduction (e.g., Barrett et al., 2001). The finding that households' access to the internet is important for consumption

growth is in line with the idea that improved connectivity is a key factor in rural development (Malecki, 2003). There is also a positive association between households' access to credit and remittances and consumption, which is consistent with the finding that credit and additional income via social ties (migrated family members) are key determinants of household income and risk minimizing strategies (Bigsten, 1996; Ellis, 2000). The positive relationship between a higher initial diversity in industries and consumption point to the importance of market linkages and external economies of scale present in urban areas for the possibility of households to improve their wealth (Ali & Peerlings, 2016). Results also show a negative and significant coefficient for distance to the nearest road. This supports the idea that farmers with better access to transportation infrastructure are in a better position to improve their welfare as this implicitly implies improved possibilities to market their produce.

5 Conclusions

The government of Rwanda has, through several economic and social reforms targeted towards poverty. the development of the poor households in the country. The aim is to push poor households towards a trajectory leading them to a higher economic wealth and better standard of living. Numerous of these policies focus on the agricultural sector since this it main source of income for these struggling households, particularly in rural areas. This article's primary focus is the "One Cow per Poor Family" program in Rwanda, also known as the Girinka programme. As the name entails, a household receives a cow from the government with the aim to improve the economic situation for the household but also generate spillover effects to community. As in all cases where a government is implementing a policy, it is crucial to evaluate its effects and efficiency to optimize planning and implementation. Girinka program was initially implemented in 2006, and by the data used in the analysis it may be too early to capture the long-term impact of the policy. However, on a household level, these types of policies need to have an immediate effect which is why this analysis is important.

We measure the outcome of the Girinka programme for the participating households, both in terms of growth of consumption and crop production. To do this, we use a matching technique that enables us to control for a potential selection bias and placement effect embedded in the programme. By use of the matching technique we are able to reduce the heterogeneity in the distribution of covariates in the treated and

control groups by a magnitude of four. The findings show that beneficiaries of the Girinka programme increases households' crop production, possibly caused by an increased supply of organic fertilizers, organic manure and soil nutrients, supporting previous literature. When allowing for interaction effects with the household's initial endowment of livestock and land, the results point to the importance of knowledge and experience of caring and handling livestock (goats or other smaller rudiments), which can be applied to the livestock received through Girinka.

If this is the case, smaller ruminants can generate knowledge and experience which can be a gateway to enter the full program. So, a policy where the households' initial characteristics can be used in the implementation may be more fruitful to optimize the impacts in the short- as well as the long run. This does not imply a narrower demarcation of potential program participants but rather a more custom-made implementation in terms of training and support. This type of step-wise program introduction can also be a solution to the potentially problematic perspective of Girinka when households may end up in poverty-traps. This is when all resources are dedicated to the cow and less time is spent on other more productive activities. Thus, it is not reasonable to assume that extremely poor households have all resources to care for a such a large live-stock as a cow. Distributing goats, specifically dairy goats, has proven more successful than dairy cattle when distributed to the poor, although such effects are not yet well documented in literature (an exception being Klapwijk et al. 2014).

Based on these findings we recommend that the program should be redesigned to better account for the specific pre-requisites of poor households, primarily with a focus on knowledge and infrastructure. The policy should therefore have a sequential design where smaller ruminants are distributed in the initial phase and offer continuous technical assistance. This would improve the shift from smaller ruminants to growing cows, which can generate higher economic wealth.

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