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

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ABSTRACT

This study estimates the effects of the one cow policy on per capita consumption and the value of per hectare crop production in Rwanda using a random sample of households observed twice (2010 and 2014). A model that accounts for heterogeneity across households and the selection bias and placement effect associated with the policy 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. Results point to the importance of household's knowledge and experience of rearing livestock for the outcome of receiving a cow.

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1. Introduction

Agricultural productivity growth is often recognized as one of the most important factors to alive poverty and achieve economic growth in the context of developing countries (Johnston & Mellor, 1961; Jalan & Ravallion, 2002). This follows the evidence that there are backward and forward linkages between the agricultural sector and other sectors of the economy and that agricultural productivity growth spurs growth in the economy as a whole (Haggblade, Hazell & Reardon, 2010). In Rwanda, most poor households are found in rural areas and they depend on agriculture as their primary source of income and employment. Specifically, around 80% of the population live in rural areas and rural poverty is estimated to be almost three times as high as urban, 44% versus 16 (National Institute of Statistics of Rwanda (NISR), 2016). Hence, poverty and living standards of rural households in Rwanda, as in most of sub-Sahara, are strongly related to agricultural assets, 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 distributes dairy cows with the overall goal to reduce poverty and provide a source of nutrition, fertilizers and additional income among the poorest households. Since its introduction in 2006, Girinka has distributed around 300 thousand dairy cows, with the intention to reach more than 350 thousand by the end of 2017 (Republic of Rwanda, 2015). Similar livestock-oriented policy programs are gaining popularity across Africa and several countries have introduced policy programs, alike the Girinka, to increase livestock ownership with poverty alleviation as the main goal.[1]

Despite the significant amount of public resources allocated through Girinka, 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.[2] 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 study addresses heterogenous treatment effects which is an attempt to examine if there are outcome differences of program participation

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[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 the Democratic Republic of the Congo.

[2] 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).

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depending on household characteristics. Having access to data that track households over time enables us to unravel if such effects exist while controlling for time-invariant unobservable factors. 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 rear livestock (Byiringiro & Reardon, 1996).

Assessing the impact of policies on welfare indicators is challenging from a methodological point of view. One may risk a selection bias in terms of type of participants, potentially based on educational- or skill levels, geographical location etc. This means that it can be difficult to interpret the effect of the 'One cow policy' as it may not be randomly dispersed but targeted to poor households. The poorest are, however excluded from the program since they do not meet the pre-stated requirements, but there might still be a 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; Nilsson, 2018a). 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 matching technique to handle selection bias and can thereby provide new evidence on the heterogeneous effects associated with Girinka. Using the CEM matching technique, we can reduce the heterogeneity in the distribution of pre-treatment covariates in the treated and control groups by a magnitude of 1.5. Findings show that the Girinka program has a positive effect on the value of per hectare crop production, indicating that the livestock has enabled households to improve their agricultural productivity. The effect on consumption depends 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 through Girinka. Results also indicate that the program may not be able to target the poorest participants as they typically lack sufficient resources and experiences to make productive use of a cow. Although the results in this study are consistent with the idea that cattle are productive resources on the farm (Pender, Nkonya, Jagger, Sserunkuuma, & Ssali, 2004; Kato, Ringler, Yesuf, & Bryan, 2011), the analysis cannot unravel the mechanisms behind this because of data limitations. In this respect, this study opens for further studies that attempts to disentangle the underlying effects, through qualitative approaches and interviews with Girinka beneficiaries.

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 and reduced malnutrition. The policy was implemented in November 2006, as a part of the Rwandan vision 2020 to move from a low-income to a middle-income country (Republic of Rwanda, 2000). The program is launched and designed by the Rwandan government and implemented through several governmental authorities including the Ministry of Agriculture and Animal Resources (MINAGRI). Alongside the governmental agencies, several non-governmental organizations (NGOs) have been involved in the program.[3] The program logic is that one poor household receive a dairy cow and, as a refund to the government, they give their first female calf to another member of the community (the bull-calves are usually sold for meat production and the money should be used to buy a heifer). This is called a credit revolving scheme (kuziturirana).

In Rwanda, livestock is considered a key factor in poverty reduction and there is a strong cultural factor embedded in the ownership of dairy cows. They signal wealth, prestige and social status and the giving and receiving of a cow in the Rwandan culture is attached with strong value and meaning (Ezeanya, 2014).

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 regulated by the government of Rwanda and are used to assess eligibility:

- The beneficiary has no cow already;
- The beneficiary has a constructed cow shed;
- The beneficiary has at least between 0.25 and 0.75 ha 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 has no other source of income;
- The beneficiary should show good farming activities.

2.1. The role of livestock in poverty reduction

There are several reasons that livestock is considered a source of advantages for rural households that depend on agriculture. Livestock improves food security through the supply of high value protein, milk and meat, which are often limited in the diets of the poor (Rawlins, Pimkina, Barrett, Pedersen, & Wydick, 2014). Livestock is also a productive asset on the farm that can assist cropping activities and supply organic manure and soil nutrients, which are cost-effective and sustainable fertilizers (Tilman, Cassman, Matson, Naylor, & Polasky, 2002; Kato et al., 2011). The water retention capacity of organic manure has the effect of reducing the risk of soil erosion (Lal, 2004), which is a significant problem in Rwanda due to topography, terracing and vulnerability to climate change (Byiringiro, & Reardon, 1996; Calzadilla, Zhu, Rehdanz, Tol, & Ringler, 2013). Liu et al. (2013) show that organic manure is crucial for the maintenance of agro-ecosystems in areas with widespread terracing as it leads to improved water retention capacity as it increases the soil water storage in no growing seasons. Ownership of livestock is also positively associated with agricultural productivity. Pender et al. (2004), for instance, address strategies to increase agricultural productivity and reduce land degradation in Uganda. They show that households with fewer livestock units have lower agricultural productivity. Households can also use livestock as a buffer for consumption smoothing against the risk to generate income. Hayami and Ruttan (1970) develop a framework

[3] The largest NGOs involved in this program were Heifer International and Send a Cow. The NGOs have played a large role in the implementation of the program and the project initiated by Heifer International in the early 2000's was used to provide inputs when designing the program (Umurerwa, 2015). The NGOs have also in some cases gone beyond just being the supplier of the cattle but viewed their engagement as one that follows over several years which has had a positive outcome for the beneficiaries (Argent, Augsburg, & Rasul, 2014).

to model agricultural assets as determinants of agricultural productivity in the context of developing countries. They show that land and livestock represent a form of capital accumulation that embody inputs supplied primarily by the agricultural sector. Following this view, livestock and other agricultural assets are particularly important assets for households that operate under conditions of high risk and uncertainty linked to changes in external conditions (Rosenzweig & Binswanger, 1992). The rationale is that, in the absence of well-functioning credit markets, households that are sufficiently risk averse will save for the future to smooth consumption. Hence, livestock can be viewed as a form of saving which can lead to increased future consumption and to reduced uncertainty in future consumption (McPeak, 2006; Kazianga & Udry, 2006; Andersson, Mekonnen & Stage, 2011). Households may, 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, Taylor, Stamoulis, Lanjouw, & Balisacan, 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.

One should not evade the issue of challenges associated with the cattle ownership and efficient cattle management. One potential obstacle in Rwanda is land fragmentation which hampers an efficient use of organic manure simply since it needs transportation between different plots. Through interviews with Girinka participants in Rwanda these long distances are brought up as a main challenge (Kim, Tiessen, Beeche, Mukankurunziza, & Kamatari, 2013). The implication is that households need both the knowledge of manure usage as well as means of transportation. The other big issue of Girinka concerns the livestock health and diseases that kill cows and reverse the beneficiaries' expectations. This implies that more field workers and veterinary practitioners are needed to assist the beneficiaries and provide post recipient support to help them achieve the expected results. One could potentially use the animals as draft power however this is rarely done among the interviewed Girinka beneficiaries.

3. Model and methods

The empirical approach to assess the effects of receiving a cow on household consumption 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 (NISR) in Rwanda that includes welfare indicators of a random sample of around 14 400 households across the country, 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 were surveyed in both rounds are included in our dataset. Hence, the data used for the empirical of this paper is a balanced panel of 3 840 observations and the sample of the 1 920 panel households were selected by the National Institute of Statistics of Rwanda (NISR) to be representative at the national and urban/rural levels (National Institute of Statistics of Rwanda (NISR) (2016)).[4] Having access to a sample of households observed in two points in time, our baseline equation can be expressed as:

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

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

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

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

First-differencing yields:

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

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

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 Girinka participation of household i at time $t = 2014$. Specifically, the treatment dummy takes the value one if the household has received a cow through Girinka between 2010 and 2014, but not in 2010 and zero if the household never received a cow through Girinka.[5] Eq. (5) implies that time-invariant factors that could influence the outcome of receiving a cow are controlled for in the estimations. However, there are also additional factors that could influence the outcome, for example if the distribution of cows through the Girinka program is not random but targeted to households with specific characteristics. As discussed in Section 2, the distribution of Girinka cows is coupled with eligibility criteria and targets a specific type of households. Should this not be accounted for, the estimated outcome could be biased.

Since it is not possible to directly observe the counterfactual mean difference in the outcome i.e., the average treatment effect on treated, our approach is to estimate a control group with distributional characteristics as similar as possible to the Girinka participating households using the CEM method.[6] According to Iacus, King, and Porro (2011, 2012), the main argument for the CEM is that it improves the balance between the treatment and the control group as the factors causing heterogeneity between the groups are assessed before the estimations. The CEM is also shown to be an efficient matching method when applied to small samples with large variation in the data (King & Nielsen, 2016; Wells et al., 2013; Nilsson, 2017, 2018), which is the case for the data used in the present study.[7] Following the approach of previous studies (mentioned

[4] See NISR 2016 (page 6) for a detailed description of the construction of the panel from EICV3 and EICV4. See Nilsson (2018) for a comparable methodological approach.

[5] The households that reported they received a cow through the Girinka program prior to 2010 were excluded from the sample (62 households).

[6] 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 E [y 1 i − y 0 i] {\displaystyle E[y_{1i}-y_{0i}]} $T = 1$ 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.

[7] The reason why propensity score matching (PSM) was not used in our paper is that the PSM has the tendency to increase the imbalance between the two different groups (treated and control) compared to the CEM. As the imbalance is at the core of the matching and where increased imbalance leads to inefficiency and bias results (King & Nielsen, 2016) we prioritize CEM. In addition, given the data used in the estimations where we combine binary variables with continuous variables, the CEM method is more suitable compared to the PSM (King & Nielsen, 2016). CEM also allows the use of more units of observations in the matching which enhances its properties (Wells et al., 2013).

above), we temporarily coarsen each pre-treatment covariate, before the regression analysis, use the coarsened variables in the matching, and use the uncoarsened values of the matched units in the subsequent regression analysis. The matching procedure generates the following weights (Iacus, King, & Porro, 2012):

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

where $T_i = 1$ and $T_i = 0$ indicate the treated and untreated units respectively and A denotes 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 denotes all the matched observations for the treatment level $T_i = 0$ within stratum A. Iacus et al. (2012) show that including the weights (Eq. (6)) in the subsequent regression analysis is equivalent to a difference-in-difference. They also show that the inclusion of control variables, including those used in the matching, is able to control for the remaining heterogeneity between the groups as it is impossible to fully account for all the heterogeneity between the groups. Hence, we estimate the following weighted fixed effects model:

$$\Delta y_{i2}^{'} = \gamma_0^{'} + \lambda_1 \Delta T_{i2}^{'} + \lambda_{i2} \Delta \boldsymbol{X}_{i2}^{'} + \Delta \varepsilon_{i2}^{'} \tag{7}$$

where y_{i2} denotes the dependent variable of household i, T_{i2} denotes Girinka 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 weights defined in Eq. (6). One limitation with our approach is the inability to account for duration and effects linked to the timing of receiving a cow. The data does not allow us to identify which year the beneficiary received the cow through Girinka, but only provide information if the household received a cow prior to 2010 or at some time between 2010 and 2014. Given the available data and the limitation that households can only be observed twice, households that received a cow between 2010 and 2014 (but not prior to 2010) are compared to households that had never received a cow through Girinka program. This implies that we match the control group based on a set of relevant pre-treatment characteristics observed in 2010 (see Section 3.3 and Table 2).

3.1. Dependent variables

This study uses two dependent variables to assess the effects associated with the Girinka policy. The first is a proxy for agricultural productivity included to test if farms that receive a cow through Girinka have a higher growth in the value of per hectare crop yields compared to similar farms that did not. The variable is calculated as the value of crop production divided by the number of hectares of land, which is a common approach to measure agricultural productivity or land productivity (Ali & Deininger, 2015; Nilsson, 2018a).[8] The second dependent variable is household consumption expenditures defined as total annual consumption expenditures weighted by the number of household members.[9] This is used to proxy overall welfare and follows the argument that household income is an unreliable indicator of household welfare in the context of developing countries (Lipton & Ravallion, 1995). Household income varies from year to year depending on the outcome of farm production and market prices, which leads to uncertainties linked to the timing of the surveys and farmers ability to recall past crop sales and prices (Ellis, 1998). The variable used to indicate total annual consumption expenditures is given in the EICV data and it is estimated with respect to time, subgroup, in terms of poverty levels, and urban rural location (see National Institute of Statistics of Rwanda (NISR), 2016), p. 7 for a detailed description). The log of per capita consumption is used in the estimations to account for heteroscedasticity and size effects.[10] Table A1 in Appendix A provide definitions of the variables and Table B1 in Appendix B reports the summary statistics. Table B1 displays summary statistics split by participation in Girinka in terms of simple mean value comparisons. Summary statistics show that a total of 122 household in the sample were granted a dairy cow through the Girinka program between 2010 and 2014, of which 45% are in the Eastern province, 28 in the Southern province, 19 in the Northern province, and 8 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 8% of the households, which can be compared to the national average which is around 1.5% (in 2015). Simple mean value comparisons show that households' expenditures on agricultural inputs are fairly equal among the groups. Average real expenditures on fertilizers is 6.8 thousand Rwanda francs among the treated and 6.5 among the non-treated. The table also displays comparative statistics regarding agricultural production, measured in value per hectare, which is indicated to be 286 among the nontreated farms and 313 among the treated. Differences in socioeconomic characteristics show that female headed households are to some extent overrepresented among the treated (0.32% versus 0.27%) and the treated also have less education and older heads compared to the nontreated.

3.2. Household and geographical controls

Household controls include measures of human capital (education and age), productive assets (land and livestock holdings alongside other productive assets) and access to capital through credit and remittances. These are assumed to lower transaction costs and information barriers and result in improved access to financial capital (Bigsten, 1996; Ellis, 2000; Barrett, Reardon & Webb, 2001; Nilsson, 2018b). Access to land and livestock are also key variables as they are productive assets on the farm and as they can be used as collateral (Abdulai & CroleRees, 2001). Tenure is another important control variable which can be assumed to improve households' access to credit (Deininger & Feder, 2009) as studies have found that weak or undefined land rights is negative for investment and productivity (Pritchard, 2013). A variable to control for land ownership is therefore included (see Table A1 in Appendix A for variable definitions and Table B1 in Appendix B for summary statistics). The model also includes variables to control for market access through the distance to all weather roads, which can lead to improved employment opportunities and lower costs of marketing farm output (Ellis, 2000). Having access to roads also has the potential to improve agricultural production by linking plots and activities in rural areas. Membership to farmer groups (cooperation) and household's expenditure on various types of agricultural inputs (organic fertilizers, chemical fertilizers, improved seeds and irrigation etc.) are also included to further control for household's access to productive assets and external knowledge.

One limitation is the inability to control for household's access to support and knowledge related to the cow, after receiving it. The

[8] 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).

[9] The models have also been estimated using consumption per adult equivalent as the dependent variable and the results are essentially the same.

[10] The questionnaires of the EICV surveys remained essentially the same across the EICV 3 and EICV 4 surveys with regard to the measurement of consumption expenditures (NISR, 2016).

data does not hold information about household's access to such services and there is no single variable that could be used as a proxy. Although this may be a matter of concern, Rwanda's governmental extension service system has a low budget and there is no service program directly related to Girinka (Kiptot & Franzel, 2014). This is a potential risk in terms of Girinka effectiveness and implementation as it implies a reliance on other service providers, voluntary farmer-trainers or NGO's (Hahirwa & Karinganire, 2017; Kiptot & Franzel, 2014). Because of data limitations, it is not possible to control for household's access to such service providers. However, the ability to use manure in an efficient way is very much related to knowledge and the ability to introduce new methods of tillage. The variables included to control for human capital (higher education, age) and membership in cooperation can be assumed to capture a part of this adoption capacity (Cohen & Levinthal, 1990).

Locational factors can influence the growth of consumption and value of crop production. Access to urban areas and diversified economic environments is one well used determinant as farm households located in areas with a more diversified industrial structure should have a greater potential to develop economies of scope in production, which makes them more flexible to adapt to changing external conditions (Hansson, Ferguson, Olofsson & Rantamäki-Lahtinen, 2013; Barnes, Hansson, Manevska-Tasevska, Shrestha, & Thomson, 2015). To account for such effects, this study follows Nilsson (2018b) and uses an entropy measure of industrial diversity (D_r),calculated with respect to the share of employees that work within different industries using the four–digit and the two–digit ISIC codes in the following:[11]

$$D_r = \sum_{g=1}^{G} E_g lnE_g \qquad (8)$$

where E_g denote the share of total employment in each district that belong to the same two–digit level where $g = 1, \cdots, G$. Hence, the measure captures variety in industry composition for the district and ranges from 0 to lnG. Zero industrial diversity implies that all employees are in the same 2-digit industry. The measure is calculated using the district level as reference, the main administrative unit in Rwanda.

Summary statistics show that households that received a cow are not a random sample. Wealth indicators (higher education, access to credit and remittances) are higher among the households that never received a cow through Girinka. The consumption of non-treated households is approximately 1.7 times higher compared to the treated. Because of the selection criteria used to assess eligibility into the one cow program, Girinka is not available for the poorest households, since they often lack the resources necessary to rear a cow. Hence, it is reasonable to expect a larger variation within the non-treated group since it is composed of the poorest households *and* those whose income is too high to become eligible. This is reflected in the descriptive statistics (Table B1 in Appendix B) showing that the variation of most variables is larger in the non-treated group, in some cases as much as twice or three time as high.

3.3. Coarsened exact matching

In selecting the pretreatment variables, we consider the criteria used to select households into the Girinka program, discussed in Section 2. Pre-treatment variables are presented in Table 1 and results from the CEM are presented in Tables C1 and C2 in Appendix C. As mentioned above, the treatment group consists of households that received a cow from Girinka between 2010 and 2014 (but not prior to 2010) and the control group consists of those that reported they had never received a cow through Girinka program. This implies that the control group is estimated based on a set of pre-treatment variables observed in 2010. The first variable is a proxy for poverty using annual consumption expenditure and the categories extremely poor, poor and non-poor (National Institute of Statistics of Rwanda (NISR), 2016). This is included to consider that the poorest households that lack the necessary resources to rear a cow, and the non-poor are not eligible to receive a cow through Girinka. The amount of land, households' access to pasture and their ownership of cattle are included to account for 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 a balanced match on all pre-treatment covariates, it guarantees that the treated households are compared to similar households in terms of poverty status, location (by province), access to land and pasture.

Table 1
Pretreatment variables.

Variable	Definition
Poverty[a]	Equals 1 if the household is non-poor; 2 if the household is poor; 3 if the household is extremely poor
Province	Location in Kigali City, Northern province, Southern province, Eastern province or Western province
Land	Number of hectares of land
Cattle	Number of cows
Pasture	Dummy equals 1 if the household has access to pasture

[a] The poverty categories are estimated using consumption levels by National Statistics of Rwanda (NISR, 2016), where poor and extremely poor households have annual consumption expenditure below 105 064 Rwandan Francs (100 = 2014) and non-poor households have annual consumption expenditure that is above 159 375.

Results from the CEM indicate that the matching reduces the heterogeneity between the treated households and the controls. By comparing the post-match imbalance results of the CEM with the pre-match imbalance reported in Table C1, we can see that the match produces a reduction in heterogeneity between the groups, not only in the means, but also in the marginal and joint distributions of the data. The overall heterogeneity between the groups is indicated by the multivariate L1 distance, which is 0.475 in the pre-match imbalance test and 0.312 after the CEM. This indicate that the heterogeneity between the groups is reduced by a factor of 1.5.

4. Regression results

Results using per capita consumption and per hectare value of crop production as dependent variables are reported in Table 2 in three model specifications. Results reported in the first column are included for comparison and show the results from estimating a model without the CEM weights. Results from simple mean value comparison indicate a significant and negative association between program participation and per capita consumption. The subsequent column in Table 2 reports the results from the estimation that include the weights, Eq. (7), with per capita consumption as the dependent variable. Including the weights, the treatment effect is 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 through the Girinka program. Simple mean value comparisons capture effects linked to the assignment of the dairy cow i.e., that the policy targets poor households that have a lower level of

[11] ISIC codes refer to the customized international standard industrial classification used to define economic activities in Rwanda. The data comes from the Establishment Census of 2010 conducted by the National Statistics of Rwanda.

Table 2
Effect of program participation on household consumption and crop production. First difference (FD) estimations and first difference estimations with match control group (FD-CEM).

	Log of per capita consumption		Log of per hectare crop production
	FD Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)
Girinka	−0.08* (0.023)	0.03 (0.04)	0.41* (0.100)
Size	−0.52* (0.02)	−0.51* (0.02)	0.52* (0.15)
Age	−0.03 (0.03)	−0.06* (0.03)	0.45* (0.17)
Gender (1 = female)	−0.16* (0.02)	−0.08* (0.03)	0.29* (0.13)
Higher education	0.94* (0.07)	0.94* (0.09)	0.14 (0.25)
Savings	0.04* (0.002)	0.04* (0.002)	0.03 (0.04)
Credit	0.02* (0.002)	0.02* (0.002)	0.02 (0.02)
Remittances	0.01* (0.002)	0.01* (0.002)	0.01 (0.01)
Internet access	0.84* (0.09)	1.20* (0.13)	−0.18 (0.10)
Land (ha)	0.07* (0.01)	0.02* (0.001)	−0.54* (0.01)
Livestock	0.07* (0.01)	0.07* (0.01)	0.44* (0.04)
Fertilizers	0.01* (0.002)	0.01* (0.003)	0.16* (0.01)
Productive assets	0.01* (0.00)	0.02* (0.00)	0.10* (0.01)
Tenure	0.01* (0.00)	0.01* (0.00)	0.16* (0.00)
Cooperation	0.21 (0.22)	0.10 (0.11)	0.10 (0.11)
Distance road	−0.007* (0.001)	−0.007* (0.001)	−0.00 (0.01)
Industrial diversity	0.80* (0.10)	1.00* (0.12)	−0.70 (0.52)
Province	Yes	Yes	Yes
District	No	No	No
Constant	12.30* (0.12)	12.17* (0.16)	5.50* (0.70)
w_i	No	Yes	Yes
Matching algorithm	–	1	1
R square	0.50	0.51	0.64
Obs.	3782	3782	3777

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

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.

Findings show that participation in Girinka has a positive effect on household crop production, reported in the last column. This could indicate that the cattle have enabled households to become more productive on the farm. As discussed, dairy cattle are found to be productive assets 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 positive effect on crop production 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. Although the results are consistent with the idea that cattle are a productive resource on the farm (Pender et al., 2004; Kato et al., 2011), the analysis cannot unravel the mechanisms behind. Data limitations do also prevent us from assessing the long-run effect of program participation as there are only two available rounds of survey data that return to the same households in Rwanda, which cover a relatively short period of time. A longer time span would be more appropriate to address effects on households' overall wealth, which could be proxied by consumption growth.

One concern could be omitted geographical factors that influence households' capacity to produce fodder and reproduce livestock, which influences the results. Such factors can be related to climate, soil fertility, topography and other factors that increase the risk of soil erosion (Helgeson, Dietz, & Hochrainer, 2012). The adoption of improved water management (irrigation) and efforts to soil conservation (protection against erosion), for instance, tend to be coupled with district belonging in Rwanda (Clay, Reardon, & Kangasniemi, 1998). There may also be placement effects if the assignment of dairy cows is not randomly dispersed but concentrated to locations with better agricultural potential. Based on what has emerged from previous literature, it seems like agricultural programs in Rwanda are provided in greater supply to those districts that have better agricultural prerequisites (Nilsson, 2017). To address if unobserved correlations linked to economic, political or environmental factors influence the results, the model (Eq. (7)) is estimated with the cluster-robust option using districts, which is the most relevant administrative and political unit in Rwanda. These results are presented in Table 3 and show no difference to the main results.

Another concern is that there may be effects linked to households' ability to rear livestock, which can be related to agricultural assets, agricultural training and experiences of livestock rearing, discussed above. To test this, we introduce interaction effects between Girinka participation and household ownership of land and livestock (goats and smaller ruminants). These results are presented in Table 4. Including interaction effects between Girinka participation and households' agricultural asset endowments (ownership of land and livestock) gives a more detailed picture. Households that own a lot of land and other types of smaller livestock units are indicated to be positively affected by participating in the Girinka program. These results can be reflective of a wealth effect, 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 proves the argument that Girinka may not benefit the poorest recipients as they are unable to provide enough fodder for the cow. Results could also be reflective of scale economies and learning effects and 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

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

	Log of per capita consumption FD-CEM cluster Coef. (Std. Err.)	Log of per hectare crop production FD-CEM cluster Coef. (Std. Err.)
Girinka	0.06 (0.07)	0.37* (0.18)
Size	−0.52* (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)	−0.18 (0.50)
Land (ha)	0.02* (0.001)	−0.55* (0.01)
Livestock	0.05* (0.01)	0.44* (0.11)
Fertilizers	0.01* (0.003)	0.16* (0.01)
Productive assets	0.03* (0.00)	0.11* (0.01)
Tenure	0.01* (0.00)	0.17* (0.00)
Cooperation	0.11 (0.11)	0.09 (0.10)
Distance road	−0.007* (0.001)	−0.001 (0.004)
Industrial diversity	–	–
Province	No	No
District	Yes	Yes
Constant	12.19* (0.16)	5.21* (0.70)
w_i	Yes	Yes
R square	0.48	0.65
Obs.	3782	3777

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

Table 4
Effect of program participation on household consumption and crop production. Interaction effects. Summary of main results.

Variable	Log of per capita consumption		Log of per hectare crop production	
	FD-CEM Coef. (Std.Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)
Girinka	0.11 (0.15)	0.04 (0.10)	0.41* (0.11)	0.43* (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	12.11* (0.16)	12.10* (0.16)	5.52* (0.74)	5.50* (0.74)
w_i	Yes	Yes	Yes	Yes
R square	0.48	0.48	0.64	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.

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 beneficiaries. We have tested the robustness of the results, including effects on overall protein intake. These are presented in Table D1 in Appendix D and the conclusion is that the results are robust.

4.1. Control variables

Turning to the household and locational controls, higher education and productive assets (access to the internet, land- and livestock holdings and agricultural inputs) are indicated to be positively related to per capita consumption. There is also a positive association between households' access to credit and remittances and per capita 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). However, many of the control variables are potentially endogenous as it is difficult to fully account for additional influences on household wealth as well as farmer abilities. Although this limits the interpretation of the controls, the results are indicated to be broadly consistent with the view that pull factors, such as education, especially above primary schooling, and credit access are important for poverty reduction (Ellis, 2000; Barrett et al., 2001; Malecki, 2003). One advantage using the two latest rounds of the EICVs is that the surveys return to the same households and that a panel can be formed. This mitigates the problem of time-invariant unobserved heterogeneity, which is more challenging to mitigate in repeated cross-sectional data. The positive relationship between a higher initial diversity in industries and consumption and the negative and significant coefficient on distance to road do also 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, 2011). These results support the idea that farmers with better access to diversified markets and transportation infrastructure are in a better position to improve their welfare as this provides improved possibilities to market their produce and earn non-farm incomes. However, the results should be interpreted with care as there are likely correlations between individual outcomes and geographic variables, as households' capability to improve their wealth are influenced by factors that are common in the local area or the region. Economic activity in a given area cannot be assumed independent of the characteristics of the households that live there, nor can it be assumed independent of other geographically associated variables, such as land quality (Lanjouw, Quizon & Sparrow, 2001).

Specifically, one concern may be the lack of a more precise measure of soil quality. Quality of land is in fact one of the main factors affecting water-holding capacity and sustainable agriculture (Lal, 2000, 2006). On the other hand, the model controls for changes in the use of soil enhancing agricultural inputs (organic and chemical fertilizers, irrigation and protection against erosion). These may significantly improve the physical properties of the soil

Table 5
Additional robustness tests. Summary of main results.

Variable	Log of per capita consumption		Log of per hectare crop production	
	FD-CEM Coef. (Std.Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)
Girinka	0.13 (0.14)	0.13 (0.14)	0.41* (0.10)	0.41* (0.12)
Village effect	0.03* (0.001)	0.03* (0.001)	0.01* (0.00)	0.01* (0.00)
Household and locational controls	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes
Constant	12.10* (0.15)	12.12* (0.15)	4.33* (0.56)	4.31* (0.67)
w_i	Yes	Yes	Yes	Yes
R square	0.47	0.48	0.67	0.67
Obs.	3782	3655	3777	3662

* 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. The full set of results of the robustness tests can be attained on request.

(Bandyopadhyay, Misra, Ghosh, & Hati, 2010; Chen, 2006). For the case of Girinka, there are some studies on the use of manure linked to the program. Results from household surveys show that more than 90% of the beneficiaries use manure and that this positively affects their productivity (Kim et al., 2013). The ability to use manure in an efficient way is very much related to knowledge and the ability to introduce new methods of tillage. Although we are unable to control for household's access to extension services because of data limitations, the variables of higher education and cooperation captures part of this adoption capacity (Cohen & Levinthal, 1990; Foster & Rosenzweig, 1995).

4.2. Additional robustness tests

Additional robustness tests are performed to test if changes in model specification and sample affect the results. These estimations are reported in Table 5 with a focus on the main results. One issue concerns the obligation that Girinka participating households should donate the first calf to a neighboring household. The data does not allow us to assess how many of the recipients that fulfilled this obligation and there is no variable that could be used in a straightforward way to proxy for this. As an alternative approach, we include a simple dummy variable to proxy for local spillover effects, coded one if the village has received cattle through Girinka during 2010–2014 and zero otherwise. As discussed, the policy should work in the way that it creates multiplier effects in the local communities as households are obliged to give away the first calf and they are also encouraged to share the manure among neighboring farms. Households could also benefit from knowledge spillover effects as they can learn from their neighbors by observing and by receiving information and knowledge that can assist them to rear their cattle more efficiently (Foster & Rosenzweig, 1995). The coefficient of the village effect is positive and significant indicating that such effects are present. The set of robustness tests also explores if the results are sensitive to outliers by performing a 1% trim of the dependent variable. The results are robust.

5. Conclusions

'One cow per poor family' (Girinka) is a governmental program in Rwanda with the aim to increase household's economic welfare and generate spillover effects in the local communities. By using household-level data across Rwanda in 2010 and 2014, we employ a matching method (CEM) to examine differences between program participating households and similar households that did not participate (Iacus, et al., 2009, 2011, 2012). We estimate the effects of receiving a cow by focusing on household consumption and the value of crop production.

The findings show an increased value of crop production among beneficiaries, possible derived from an increased supply of organic fertilizers (Klapwijk et al., 2014). The effect can be calculated to an increase in value of crop production by approximately 400 Rwandan Francs. Given the cost of a cow (prices range between 100 000 and 500 000 Rwandan Francs), this annual increase is rather small. However, to calculate the overall effects of the program one also must add potential local spillovers resulting from the program. The Girinka beneficiaries are required to give away the first-born female calf to another community member. As approximately one-third of the Girinka cows were in-calf when they were given to the households, and some even carry more than one calf (Argent et al., 2014), the effect of Girinka is likely to be greater than just measuring the effect of the first receiving household. Our results confirm this via the significant village effect. The give-away set up is an important part of the sustainability of the program as the possibility to give-away a calf has to be viewed in the cultural setting and the give-away can also serve as a bridge between groups in the community (Ezeanya, 2014).

The combined effect of a households' initial ownership of livestock/land *and* being a beneficiary in Girinka show that previous experience of handling livestock and initial land endowments enhances the effect. These results indicate the importance of knowledge and experience for the outcome of receiving a cow through Girinka. These results could also suggest that prior experience of handling smaller ruminants can be a gateway to enter the full program and that a successful policy is one where households' initial characteristics are considered in the selection of beneficiaries. This does not need to imply a narrower selection of participants but a more custom-made implementation in terms of training and support. Specifically, the distribution of dairy goats has proven more successful than dairy cattle when given to the poor, although such effects are not yet well documented in literature (an exception being Klapwijk et al. (2014)).

Based on the findings in this paper one can assume that the program efficiency is higher when the design of it accounts for specific household characteristics such as initial endowments and human capital but also geographical location and access to support. By separating different types of households in the program, based on for example their poverty level, and by using different predetermined household characteristics for the different groups, the efficiency of the program can be enhanced. Also, to allow a wider diversity in type of ruminant that are given through the program it allows for a better match between the program and needs and possibilities of the households.

The data used in this paper allows us to study the overall effect on consumption and production of participating in Girinka. However, there are some important research steps to be taken to further assess the effects of the program. One such step is to study how the length of the program participation determines the outcome. Another important avenue for research is to deeper analyse the indirect community effects. From a cost-benefit view of governmental programs, spillover effects can potentially be an important part.

A third step is to further analyze our main results that household production increases when they receive a cow. Our data do not allow us to disentangle the underlying mechanisms, but we know that a cow can be used as draft power, produce organic manure and bio-gas. By all these uses, one can also increase the production of crops and improve yields. To further study this, we suggest a comprehensive qualitative approach to not only assess the Girinka program but shed insights into the underlying factors that enhance productivity in general within the setting of developing countries.

Conflict of interest statement

The authors hereby assure that:

- there are no potential conflicts or undisclosed relationships that may pose conflicts of interest,
- there are no undisclosed funding sources that may pose a conflict of interest.

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Appendix A

Table A1
Variable definitions[*]

Variables	Definition
Consumption	Per capita consumption expenditures adjusted for poverty and spatial and temporal variations in prices. Measured in thousand Rwandan Francs, real values where 2014 is the base year (2014 = 100)
Crop production	Total annual value of crop production estimated by the household using market prices and divided by the number of hectares of land. Measured in thousand Rwandan Francs, real values where 2014 is the base year (2014 = 100)
Girinka	Treatment dummy equals 1 if the household received a cow through Girinka between 2010 and 2014; zero if the household did not receive a cow through Girinka prior to 2010 or between 2010 and 2014
Girinka × Livestock	Interaction dummy of the treatment dummy Girinka (defined above) multiplied by Livestock (defined below)
Girinka × Land	Interaction dummy of the treatment dummy Girinka (defined above) multiplied by Land (defined below)
Size	Number of household members
Age	The age of the household head
Gender	Dummy equals 1 if the head of the household is female, 0 otherwise
Higher education	Share of household members that have education above secondary (university or advanced secondary)
Savings	Total annual household savings. Measured in thousand Rwandan Francs, real values where 2014 is the base year (2014 = 100)
Credit	The amount, cash value, of credit. Measured in thousand Rwandan Francs, real values where 2014 is the base year (2014 = 100)
Remittances	The amount, cash value, of remittances. Measured in thousand Rwandan Francs, real values where 2014 is the base year (2014 = 100)
Internet access	Dummy equals 1 if the household has access to internet through mobile phone or wireless network, 0 otherwise
Land	Number of hectares of land cultivated by the household.
Fertilizers	Total expenditures on improved seeds, organic fertilizers, chemical fertilizers and pesticides. Measured in thousand Rwandan Francs, real values where 2014 is the base year (2014 = 100)
Productive assets	Total expenditures on other productive assets. Measured in thousand Rwandan Francs, real values where 2014 is the base year (2014 = 100)
Tenure	The share of cultivated land plots that have documented rights in the form of a lease certificate
Cooperation	Dummy equals 1 if the household is a member of a farmer cooperation, 0 otherwise
Livestock	The total number of livestock (cattle, goats and other animals) owned by the household
Distance road	Distance in minutes from the house to the nearest all weather road, estimated by household
Industrial diversity	The diversity of industries in the district calculated using ISIC codes and with respect to the number of employees (based on Eq. (8))
Province	Dummy variables indicating in which province the household is located (Kigali City; North province; South province; East province; West province)

[*] In the estimation a first-difference model is used capturing the change from 2010 to 2014.

Appendix B

Table B1
Summary statistics and simple mean value comparisons between treated and untreated households.

	N	Mean	Standard dev.	Min	Max
Non-treated (never received a cow from Girinka)					
Consumption	3689	368R	642R	10.95R	1860R
Crop production	3689	286.61R	287.03R	0	1000R
Size	3689	4.67	2.22	1	22
Age	3689	44.25	15.68	16	98
Gender (1 = female)	3689	0.27	0.44	0	1
Higher education	3689	0.06	0.18	0	1
Savings	3689	676.11R	199R	0	1200R
Credit	3689	349.37R	369.32R	0	1800R
Remittances	3689	32.79R	20.18R	0	8681R
Internet access	3689	0.02	0.15	0	1
Land (ha)	3689	0.70	1.72	0	65.97
Livestock[a]	3689	3.70	26.74	0	1232
Fertilizers	3689	65.53R	485R	0	2523R
Productive assets	3689	89.21R	301R	0	2653R
Tenure	3689	0.65	0.36	0	1
Cooperation	3689	0.02	2.21	0	1
Distance road	3689	6.71	9.38	0	60
Industrial Diversity	3689	0.80	0.16	0.46	1.05
Kigali City	3689	0.24	0.43	0	1
North province	3689	0.22	0.41	0	1
East province	3689	0.18	0.38	0	1
West province	3689	0.20	0.40	0	1
South province	3689	0.23	0.42	0	1
Treated (received cow from Girinka between 2010 and 2014 but not prior to 2010)					
Consumption	122	217.73R	188.21R	272.45R	1654.60R
Crop production	122	313.03R	207.93R	0	8619.0R
Size	122	5.35	2.29	1	11
Age	122	50.89	16.15	21	94

(continued on next page)

Table B1 (*continued*)

	N	Mean	Standard dev.	Min	Max
Gender (1 = female)	122	0.32	0.46	0	1
Higher education	122	0.03	0.08	0	0.5
Savings	122	240.71R	795.26R	0	6000.0R
Credit	122	37 874	69 311	0	500R
Remittances	122	20.18R	84.40R	0	750 000
Internet access	122	0.04	0.20	0	1
Land (ha)	122	0.61	0.56	0	4.47
Livestock[b]	122	3.90	5.06	0	24
Fertilizers	122	68.82R	220R	0	2025R
Productive assets	122	78.56R	245R	0	2312R
Tenure	122	0.74	0.33	0	1
Cooperation	122	0.01	0.56	0	1
Distance road	122	5.56	8.77	0	40
Industrial diversity	122	0.75	0.14	0.46	1.04
Kigali	122	0.12	0.33	0	1
North province	122	0.18	0.38	0	1
East province	122	0.39	0.49	0	1
West province	122	0.10	0.29	0	1
South province	122	0.20	0.40	0	1

Notes: R denotes expenditures in thousand Rwandan Francs (RWF, 100 = 2014).
[a] Include cattle, goats and other animals.
[b] Include goats and other animals, but not the cow received through Girinka.

Appendix C

Table C1
Results of the Coarsened Exact Matching.

Imbalance test (pre-match)	L1	Mean difference	25%	50%	75%
Univariate imbalance:					
Land	0.046	−0.098	0.015	−0.003	0.014
Poverty	0.039	−0.052	0	1	0
Province	0.265	0.385	−0.003	0.008	0.014
Cattle	0.156	0.156	0	0	0
Pasture	0.011	−0.012	0	0	0
Multivariate L1 distance:	0.475				
CEM[a]					
Univariate imbalance:					
Land	0.190	−0.026	0.001	0	0
Poverty	9.2e-15	−6.4e-14	0	0	0
Province	1.2e-14	−3.3e-14	0	0	0
Cattle	1.0e-14	−1.0e-14	0	1	1
Pasture	0	0	0	0	0
Multivariate L1 distance:	0.312				

[a] Using the scott break method for imbalance. Number of strata = 57, number of matched strata = 24. Perfect balance is indicated by L1 = 0, and the maximum. L1 = 1 imply complete heterogeneity between the groups (Iacus et al., 2011).

Table C2
Number of matched and unmatched observations.

	0	1
All	3213	105
Matched	2996	105
Unmatched	217	0

Appendix D

Table D1 Presents the result from the robustness test where we also consider nutritional consequences regarding overall protein intake. A focus on protein is logic since animal food intake tends to increase with increases standard of living and decrease with economic stagnation (Steinfeld, Wassenaar, & Jutzi, 2006). Joining Girinka gives the opportunity to increase consumption through a higher standard of living which also may affect the bundle of consumed goods. We handle these concerns through using the share of consumption expenditure from protein foods as dependent variable. Comparing the results with Table 4 we can see that results are mainly the same in terms of sign and significance of effects.

Table D1
Robustness tests. Effect of program participation on household consumption of protein food. Summary of main results.

Variable	Log of per capita consumption (protein food)		Log of per capital consumption (protein food)	
	FD-CEM Coef. (Std.Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)	FD-CEM Coef. (Std. Err.)
Girinka	0.09 (0.10)	0.01 (0.01)	0.43* (0.10)	0.41* (0.13)
Girinka × land	0.02* (0.00)	–	0.03 (0.03)	–
Girinka × livestock	–	0.02* (0.00)	–	0.02* (0.001)
Household and locational controls	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes
Constant	12.09* (0.13)	12.23* (0.15)	5.41* (0.65)	5.42* (0.79)
w_i	Yes	Yes	Yes	Yes
R square	0.50	0.51	0.64	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.

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