Livestock interventions and farmer welfare in sub-Saharan Africa: A panel data analysis from Togo

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Abstract:

Using a panel data set of 445 small-scale cattle farm households in northern Togo, this paper examines the impact of disease control interventions on cattle productivity, household welfare, poverty and vulnerability. We employ difference in difference analysis to examine the impact on livestock productivity, consumption per capita and stochastic poverty and vulnerability to future poverty. We find a positive impact on improving cattle productivity, income and consumption per capita. Our results also show positive poverty reduction effects of the interventions as well as a reduction in vulnerability to poverty. We can show that the interventions have positive smoothening effects on household consumption and income. Our results are robust across different estimation specifications such as fixed effects and instrumental variable fixed effects models.

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JEL Codes: Q16, O19

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Keywords: Livestock, Poverty, Vulnerability, Interventions, Fixed-effects, sub-Saharan Africa

***JEL Classification*: C36, I30, Q10, Q16**

1. Introduction

Agriculture remains the major source of livelihood of households in sub-Saharan Africa (SSA). It offers employment to approximately 60% of the population (IMF, 2015; WDI, 2014). In order to sustain their livelihoods the rural poor need to diversify income sources and strengthen their productive assets to avoid income from falling below a critical level. Growth in the agricultural sector must continue if poverty in SSA is to decline (Ravallion et al. 2007) mainly agriculture is more inclusive than formal employment. Togo is among the countries in SSA that is faced with a high poverty rate; with 59 for the country and 91 percent in the Northern region. Similarly, incidences of undernourishment and malnutrition among children under 5 remain high (WDI, 2014).

Livestock are an important component of agriculture of households in the Northern regions of Togo. Cattle serve a multitude of purposes ranging from draft power for farm cultivation, manure, store of value (insurance), emergency income and supplementing the nutritional needs of households (Pica-Ciamarra, 2015; Kazianga and Udry, 2006). In the absence of off-farm employment opportunities, and imperfect credit market, cattle remain the only channel into the liquidity economy. However, cattle production is faced with serious constraints, major one the African animal trypanosomosis (AAT), a livestock disease that has cause tremendous economic loss in the past.

It is estimated that in the SSA region losses of about US$ 4.5 billion dollars are attributable to the disease, including trade losses, cattle mortality, disease control cost and loss of productive farm working hours (Cecchi and Mattioli, 2009; FAO, 2011; Bud, 1999). At the household level, AAT has direct negative implications on household's wellbeing such as increased vulnerability to food insecurity and reduced households' ability to mitigate idiosyncratic and systemic shocks that could lead to income loss (Liebenehm et al., 2011). For example, Affognon (2007) found that cattle farmers in Mali and Burkina Faso lose approximately €9.50 to €22.00 per Tropical Livestock Unit (TLU) p.a. as a result of AAT.

Current control and prophylactic measures remain ineffective or unsustainable and often result in drug resistance (see Clausen et al., 2011; Grace et al., 2009; Liebenehm et al., 2011). Hence an integrated approach was proposed that involves a combination of both preventive and curative measures with the goal of reducing overall disease prevalence, encourage responsible use of trypanocides to reduce drug resistance and improve the general health condition of the animals (WHO, 1987).

An international multidisciplinary team of scientists in cooperation with governmental and non-governmental stakeholders launched the so-called TRYRAC program in 2012 (www.trypanocide.eu) to improve small-scale farmers AAT management practices. TRYRAC's interventions have promoted the integrated approach to disease control include both participatory extension methods such mass media and training of selected farmers on good husbandry, tick.

In this paper we investigate whether and to what extent do livestock disease control interventions TRYRAC improve small-scale cattle farmers' welfare. We use household panel data of farmer who participated in the TRYRAC program and those who did not. We collected before and after TRYRAC's intervention took place. We proceed as follows: First, we analyze if disease control interventions improved cattle farmers' knowledge. Second, we investigate if improved knowledge enhances adoption of improved disease control practices. We assume that increased knowledge could be different from the actual adoption of practices, because the adoption decision is driven by various household, farm level and community level variables. Implicitly, this means that awareness (knowledge) and adoption (actual implementation of practice) are different parts of the same equation, i.e., improved knowledge of cattle farmers may not necessarily lead to improved welfare especially if the use of the knowledge requires additional investments. Second, we investigate the impact of disease control interventions on farm households' welfare measured as consumption per capita, poverty headcount and vulnerability to poverty.

The paper is among the first that undertakes rigorous impact assessment of livestock disease control in SSA. It thus complements recent empirical literatures on the impact of crop technologies on household's wellbeing in SSA (see Amare et al., 2012; Shiferaw et al., 2014; Asfaw et al., 2012; Kassie et al., 2011), the literature on technology impacts targeted to livestock remains scant. Our study is unique in a several ways: First, it focuses on a region characterized by high poverty, lack of formal employment opportunities and lack of credit and input markets. Thus, it provides a new insight for policy formulation that would improve livelihoods and households that remain vulnerable. Second, this is perhaps the first study that evaluates the impact of interventions in the livestock sector at the household level using panel data. Third, it looks at a broader welfare outcomes going beyond stochastic household poverty to investigate vulnerability to poverty a futuristic determinant of welfare. The rest of the paper is structured as follows. In section 2, we describe the intervention. Empirical and theoretical methods are presented in section 3. The description of the study area, data setting and collection methods presented in section 4. Section 5 presents the results and discussion while section 6 summarizes and concludes the paper.

2. Background of the TRYRAC intervention program

AAT is caused by the *Trypanosoma spp*. It is transmitted by the tsetse-fly (*Glossina spp*.). While the acute case of the disease is fatal, most cases of AAT are chronic, affecting animals over a longer time period resulting in loss of appetite, prolonged diarrhea and reduced productivity (Simarro et al., 2011). Estimates put the cost of AAT in SSA at approximately US$4.5 billion through animal mortality, lost productivity and treatment cost (Swallow, 2000; FAO, 2011). At the household level, AAT leads to production, consumption and income losses which in turn perpetuate the life of the rural poor in poverty and food insecurity (Fafchamps et al., 1998, Perry et al., 2002, FAO, 2011). The impact of AAT remain detrimental in northern Togo regarded as an AAT endemic zone. It is for this reason that the European Union through its Global Program for Agriculture Research for Development (ARD) funded the Trypanosomosis Rational Chemotherapy (TRYRAC) intervention in the region targeted at small scale cattle producers those severely affected by AAT.

TRYRAC is an international cooperation of academic, governmental and non-governmental organizations and has the aim of optimizing African Animal Trypanosomosis (AAT) management in sub-Saharan Africa specifically in Togo, Mozambique and in Ethiopia. The intervention commenced in 2012 with a funding period of 5 years with an objective to improve livelihoods of resource-poor small scale livestock (cattle) keepers in the selected countries. The intervention consisted of two components: First, using participatory extension methods (e.g. mass media and posters) to educate small-scale farmers on improve cattle production practices specifically AAT management. Second, training of farmers on good husbandry, tick and worm control strategies. In Togo, the intervention was targeted at small-scale cattle keepers in Kara and Savanes regions. For purposes of project implementation, communities were divided into intervention and control communities. Interventions were then implemented in villages by the expertise of ICAT and Veterinaires Sans Frontiers (VSF) in conjunction with the local veterinary and village cattle herder associations. The interventions were rolled out as extension programs using mass communication methods such as audio broadcast messages, posters, billboards and community outreach meetings. TRYRAC interventions did not include direct subventions such subsidies or inputs to cattle farmers.

Thus, there were no special criteria for participation. All cattle keepers in intervention villages were eligible to attend the training or extension workshops.

Villages were selected for TRYRAC based on AAT prevalence, availability of cattle farmers and the role of cattle in the household welfare triangle. This is to ensure that participants and control households would be comparable. Stakeholders comprising of the national veterinary service department, Ministry of Agriculture, cattle farmers association, input dealers and opinion leaders in study regions provided both production and disease prevalence data that has been used to select study villages.

3. Methodology

3.1. Identification and empirical estimation strategies

To identify the impact of TRYRAC, we proceed in 3 steps as follows. First, we investigate the impact of TRYRAC on AAT knowledge. Second, we investigate the impact of the intervention on the adoption of improved practices to manage AAT through its effect on improving knowledge. Finally, we estimate the impact of the interventions on welfare outcomes, i.e., consumption per capita, savings, poverty and vulnerability to poverty, through its effect on increased cattle productivity achieved by cattle health improvements. Estimation of this nature is not a trivial exercise due to potential selection-bias and endogeneity associated with the program's set up.

The availability of a panel data allows us to follow a number of quasi-experimental identification strategies to estimate the impact while addressing concerns of self-selection caused unobserved heterogeneity and potential endogeneity of the treatment decision. We implement the double-difference, fixed effects estimator, and the fixed-effects instrumental variable (FE-IV) approach address possible biases.

3.1.1. The difference in difference (DD) fixed effects

Our basic estimation model is the ordinary least squares (OLS) difference in difference approach. With a household level participation (treatment) indicator, the idea of the difference-in-difference (DD) method is to compare the average outcome of participants with non-participants before and after the intervention. Ideally, the effect of the intervention should be measured by comparing outcomes before and after the intervention of the treated, i.e., the average treatment effect on the treated (ATT) given mathematically as,

$$ATT = (Y_t \mid P = 1) - (Y_{t-1} \mid P = 0) \quad (1)$$

Where, Y_t is the mean outcome in the period after intervention and Y_{t-1} is the mean outcome in the period before intervention and P is the program participation status, which equals 1 if the respondent participates, 0 otherwise. However the counterfactual scenario is unobserved thus comparing mean outcomes between participants and non-participants could result in biased estimates. This is because difference could be driven by unobservable differences such as respondent's ability, skills and motivation rather than the effect of the intervention. Also, several factors that affect the outcome variable may change between the two time periods.

Thus, we need a comparable group that has similar characteristics as participants and exposed to same exogenous events except for the intervention variable. Aside the similarity and comparability of the two groups, a critical consideration of the DD is the common trends assumption. This states that in the absence of the intervention, the outcomes of participants and nonparticipants would follow a parallel trend conditioned on observed characteristics. If this assumption holds, any observable "change" in the outcome of the participants after the intervention could then be attributed as the effect of the intervention (Ashenfelter, 1978). If we represent two Groups A and B over periods t_0 , and t_1 . Period t_0 represents baseline condition where no intervention has been rolled out. One of the groups i.e. Group A is then exposed to an intervention at period t_1 and the other (Group B) is not. Now assume that Group B meets the characteristics as an appropriate counterfactual for Group A, then the treatment effect of the intervention using the DD estimate can be presented based on the two groups as follows:

$$DD = \alpha = (\mathrm{E}(Y_{At} - Y_{At-1} \mid t = 1)) - (\mathrm{E}(Y_{Bt} - Y_{Bt-1} \mid t = 0)) \quad (2)$$

$$\alpha = (Y_{At} - Y_{At-1}) - (Y_{Bt} - Y_{Bt-1}) \quad (3)$$

We estimate a pooled ordinary least squares DD regression for eqn. 3 of the form:

$$\mathrm{Y}_{it} = \lambda \mathrm{A}_{it} + \delta \mathrm{T}_t + \beta \mathrm{X}_{it} + \alpha (\mathrm{A}_{it} \times \mathrm{T}_t) + \phi \vee_i + \varepsilon_{it} \quad (4)$$

Where, Y_{it} is the outcome variable (knowledge score, practices, AAT input, consumption per capita, poverty and vulnerability) of the i^{th} respondent in period *t*, T_t is year dummy for period, given that other exogenous variables could drive the impact we include X_{it} a rich set of observed household–level covariates including age, education, household size, dependency ratio, farm characteristics, assets, services and infrastructure variables that controls for village fixed effects between periods t_0 and t_1, $\vee_i$ is the village dummy to control for village effects and ε_{it} is the idiosyncratic additive error term with zero mean.

Since we assume that unobserved household heterogeneity are time invariant, we also estimate a variant of the DD model as a fixed effects OLS of the form:

$$\Delta Y_{it} = \delta \mathrm{T}_t + \beta \Delta \mathrm{X}_{it} + \alpha \Delta \acute{D}_{it} + \varepsilon_{it} \tag{5}$$

All variables remains as defined in eqn. 4. T is a time dummy capturing the time fixed effects and standard errors are corrected for serial correlation[1]. In estimating eqn. 5 we implicitly controlled for pre-treatment observed time varying covariates that could be correlated with the treatment decision of respondents but remain exogenous to the actual participation decision. A key condition for the fixed effects estimation. This allows for further reduction in any possible bias that could be due to pre-treatment variations.

Although we took utmost care to reduce possible biases in our DD and FE estimation, a possible critique could still arise from a possible violation of the time-invariant assumption. Although the intervention villages are randomized, farmer participation was based on expected household utility from participation. This means that if participation decision is correlated with time varying unobservable heterogeneity, then the DD and FE estimates be biased (Wen et al., 2015; O'Neil et al., 2016). In this regard, we also check the robustness of our results from eqn. 5 by estimating a variant of the treatment effect through an individual household fixed effects instrumental variable approach. We describe this approach in the next section.

3.1.2. Fixed effects instrumental variable approach (FE-IV)

When the individual decision to participate in the intervention is not randomized as it is the case of the TRYRAC, the estimates of the OLS obtained from the FE strategy could suffer self-selection bias because of two reasons, i.e., (i) from unobserved individual heterogeneity that could affect the program participation decision and the outcome variable (also referred to as simultaneity bias) and (ii) from the endogeneity caused by program targeting to specific local characteristics (Glewwe and Miguel, 2008; Khandker et al., 2010). However, as discussed earlier, program endogeneity is not a concern because intervention villages were

[1] Intervention villages were randomly assigned and there were no parallel occurrences of other programs that differently affected participants and non-participants, which would have violated the parallel trends assumption.

randomly selected. Furthermore, intervention villages did not differ significantly in terms of any exogenous characteristics from the control villages that are likely to impact on the outcome (Table 2). The only remaining concern is self-selection bias due to unobserved heterogeneity. This is because farmers self-selected themselves into the interventions based on their personal assessment of the utility from the intervention. Since the unobserved characteristics are not captured, they become part of the error term. The result is an error term that contains variables that are also correlated with the participation decision, i.e., $\text{cov}(T, \varepsilon) \neq 0$ biasing the coefficient of the treatment effect. This violates the OLS assumption of independence of repressors and error term. To obtain efficient and unbiased results of the impact of the program intervention, we need to isolate the variation in the treatment decision and the error term.

To solve this problem, we follow Duflo et al., (2006) and Mason et al. (2017), and apply a standard two-stage least square (2SLS) instrumental variable approach to estimate the impact of TRYRAC interventions on farmer welfare. If we assume that the decision to participate in TRYRAC eqn. 5 is endogenous, the ATT of interventions through the 2SLS-IV through a 2-stage procedure as follows: First stage estimates the propensity to participate and Z is the instrument

$$D'_{it} = \beta_1 \mathrm{X}_{it} + \gamma Z_{it} + \mu_{it} \tag{6}$$

Second stage the residuals are plugged into an outcome equation as in equation 7 as follows:

$$Y_{it} = \delta \mathrm{T}_t + \beta_2 \mathrm{X}_{it} + \alpha \hat{\mathrm{D}}'_{it} + \varepsilon_{it} \tag{7}$$

α in eqn. 7 gives the ATT.

The consistency of the ATT in eqn. 7 depends on the validity of the instrument in eqn. 6. In order to be regarded as valid instrument, it should meet the following; i) uncorrelated with any covariates that directly affects the outcome of and ii) not directly affect outcome itself but conditional on treatment status. We exploit the randomness of intervention village assignment as a first instrument. From the baseline report, we found knowledge of farmers of AAT to be low. Approximately 90% of respondents do not know what to do if animals are affected. As a second instrument, we estimate and use the adoption rate in the village. We assume and argue that farmer decision are informed and shaped by their neighbor (Weyori et al., 2017). Hence if more farmers participate in TRYRAC it could have a positive influence in affecting the decision to also join these programs.

3.2. Impact pathway and outcome variable definition

TRYRAC, like any productivity enhancing technology, there are great complexities involved in understanding the impact at the household because welfare is an embodiment of many aspects of the household. For example improved livestock health could affect household welfare through at least four separate channels: First, as a source of protein through milk and meat it can improve food security and nutrition. Second, source of draft power and manure for staple crop production. Third, additional income from sale of products and services and also reduced production cost to supplement or smooth household income shocks. Fourth, livestock as a productive asset could be drawn to smooth consumption expenditure especially when staple crop production is in shortfall.

For the purpose of this study, we restrict the impact through the channels improving consumption per capita expenditure, net cattle income and reducing veterinary expenditure. Consumption per capita expenditure is defined to include all household expenditure items in the last 12 months preceding the interview date. To calculate this, we pooled the household total reported consumption expenditures at 2012 nominal prices adjusted by the adult equivalent scale. This includes all durable and nondurable goods and services consumed and used respectively by all household members.We defined net livestock income as the total gross income from livestock products less input cost (veterinary service charge plus inputs costs), feed if any, and labour if it is hired per annum. We did not consider own labour cost for caring for animals because most households in the study depended on own labour in cattle production hence costing own labour resulted in negative income.

We go a step further in our analysis to investigate how present welfare outcomes of the household also affect the household stochastic poverty outcome. Following Foster et al. (1984), we compute the Foster-Greer-Thorbecke (FGT) poverty measures (poverty incidence, poverty gap) comparing the per capita household income to the international US$1.90 per day poverty line. Given the stochastic nature of household poverty, we also estimate the impact on futuristic welfare vulnerability to poverty. Households in SSA are often trapped in either transitory or structural poverty due to the absence of forwarding looking interventions that consider their vulnerability to poverty. Following the approach of Chaudhuri et al. (2002) and Hoddinott and Quisumbing (2003) of vulnerability to poverty, we estimate the impact of

TRYRAC interventions in reducing vulnerability to poverty. We define household vulnerability to poverty V_{it} as the probability that the i^{th} household at time *t* will record a consumption that is below the poverty line defined as *z* in t+1 given a set of socioeconomic household characteristics at time t. i.e.

$$V_{it} = \Pr\left(C_{it,\,t+1} \leq Z \mid X_i, \beta_i, \varepsilon_i\right) = \frac{Z - \left(\hat{C}_i - \hat{\sigma}_i\right)}{2\hat{\sigma}_i} \tag{8}$$

We classify households with a probability threshold above 0.5 to be vulnerable to poverty and those below not vulnerable. We estimate a reduced form of eqn. 8 in the form:

$$V_{it} = \alpha T_t + \gamma X_{it} + \theta S_{it} + \delta\phi_{it} + \beta_5 D'_{it} + \mu_{it} \tag{14}$$

Where T is a binary variable indicating the before and after treatment periods capturing the time fixed effects, X_{it} time varying household characteristics, D'_{it} is the program participation status of the i^{th} household in time t, S_{it} idiosyncratic shocks reported and ϕ_{it} covariates shocks reported, μ_{it} is the idiosyncratic additive error term with zero mean.

4. Data and summary statistics of variables

4.1. Sample selection

Data for this paper is derived from the EU-funded TRYRAC project in Togo. The project has collected a panel data set of small scale cattle farmers in two rounds 2013 and 2016 representing periods of before and after TRYRAC interventions. Using a multistage sampling technique we randomly selected 8 and 12 study villages in Savanes and Kara regions respectively. Although village selection was randomized, the pool of villages had to meet a-priori defined criteria before it could be included in the sampling frame, i.e., (i) AAT prevalence and (ii) significant availability of cattle farmer households. Kara and Savane regions have the highest cattle numbers, highest AAT prevalence and AAT resistant strains in Togo (Tchamdja, 2016). Due to the high prevalence of AAT in these regions however, all villages selected had a similar prevalence across herds (about 25%). Apart from similarities of AAT prevalence, selected villages also had similar socio-economic characteristics making them comparable across different aspects. This characteristic of similarity is an important consideration for the econometric identification strategies.

Based on proportionate random sampling techniques, 25 cattle keeping households were selected from a total list of cattle farmers in each village prepared in consultation with the chef du ménage (village head) and the local veterinary office. A total of 500 households were selected for the baseline survey in 2013. First, a reconnaissance survey was implemented to collect village level information and other disease data through stakeholder interviews that included veterinarians, village chiefs/head and opinion leaders. Household surveys were implemented using a pretested structured questionnaire administered by experienced and trained local enumerators. Selection of enumerators was further refined based on ability to speak at least one of the local dialects in the study area and also understood the farming terrain. This is to reduce noise in the data given that most of the cattle farmers have little or no formal education (average is 2 years).

During the baseline survey (2013), farmers have been asked on a wide range of questions related to knowledge, attitudes and practices towards AAT and general cattle management practices in terms of worms, ticks, and feeding. These have been followed in line with the knowledge, attitudes, and practices questionnaire guidelines used in similar studies for AAT control (Tornimbene et al., 2014; Grace et al., 2009; Liebenehm et al., 2011). For details description of the questionnaire refer to Weyori et al. forthcoming. The follow up survey has been conducted in May 2016 two years after interventions have been rolled out using the same questionnaire as in the baseline year with few adjustments to identify intervention households. More than 93% of baseline households were interviewed during the impact survey with an attrition[2] rate of 6.8% or 33 households. In this study, we restricted ourselves to households that have sufficient information available in both survey waves– to form a balanced panel of 443 unique households.

4.2. Descriptive statistics

In this section we present the descriptive statistics of households. We look at livestock holding, income diversification, household demographics, knowledge and practices towards disease management. These statistics gives an outlook of the sample and the quality of the counterfactual households used in the econometric estimations. Livestock keeping is very prominent in the study area as presented in Table 1. Respondents are typically small holder

[2] Attrition was due primarily to three reasons: First, some of the households moved out of the original villages and hence could not be traced during the impact survey. Second, other households (18 households) refused out rightly to participate in the impact survey because they had expected to be remunerated during the baseline survey which was not the case. Third, the final group of households was left out on purposely because their baseline data was insufficient, missing or incomplete to allow for any useful impact analysis to be carried out.

livestock farmers with herd size ranging from 2 to 100 cattle with an average herd size of 9 cattle per household. The cows are kept mainly for reproductive purposes while the bulls are kept for traction and or as a store of value. Aside owning cattle, households also kept other livestock such as goats, sheep and chicken. Livestock disease especially AAT remains a key constraint to cattle productivity in Togo. For example more than 85% of the respondents in our sample reported the disease in their herd across the two survey waves. Table 2 presents the breakdown of the main diseases that our sampled respondents reported in their herds over the period.

Table 1: Distribution of different livestock species household keep

	2013		2016	
Livestock Type	**Percent of households**	**mean herd size**	**Percent of households**	**mean herd size**
Calves	21	7	21	6
Heifers	14	6	19	5
Cows	20	10	24	11
Bulls	25	5	24	3
Oxen	17	16	13	4
Sheep	28	10	28	15
Goats	28	8	29	9
Poultry	35	36	36	34
Pigs	7	6	6	9

Source: *Own calculation based on household survey 2013-2016*

From Table 2, our findings show a marginal drop in AAT incidence in the total sample year on year bases, although AAT still remains a constraint according to respondents. A disaggregation of AAT incidence by program participation status across the two waves show that there is a much sharper decline in the AAT incidences (about 5% points) in the intervention villages while the control villages recorded a slight increase (2% points) in AAT incidence.

Table 2: Top five diseases reported by respondents by treatment category

	2013			2016		
Disease incidence = yes	**95%**			**87%**		
Problem	***Pooled (N=443)***	***Treated (N=214)***	***Control (N=229)***	***Pooled (N=443)***	***Treated (N=214)***	***Control (N=219)***
Trypanosomosis[3]	23	27	25	25	22	27
Tick & worm	12	11	18	15	13	13
Diarrhea	13	12	3	8	14	11
Skin abrasions	8	10	10	10	7	10
Injury	6	9	7	8	5	6

Source: *Own calculation based on household survey 2013-2016*

The socio-economic characteristics of the households by participation are reported in Table 3. Households are not statistically significant different by category. Household heads are on average 49 years old, married (polygamous), poorly educated (82% with no formal education) and less diversified in terms of income sources. Household size is generally large ranging from 5 to 35 with a sample average of 10. The dependency ratio is 1.14. Crop production and livestock rearing constitute the main economic activity of in the study area contributing more than 88% of household's total income. The average farm size is 2.4 hectares and crop production is 100% rainfed.

[3] The actual percentage for AAT incidence could be higher than what is reported in Table 2 because farmers could not readily diagnose AAT but rather symptoms. For example while diarrhea and skin abrasions may be distinct sicknesses, they are also recognized symptoms of AAT..

Table 3: Descriptive statistics of the household head

Variable		Pooled HH	Control HH	Treated HH
HH head age (years)		49	49.5	49
Household age grouping (%)				
	18–24 years	2	2	2
	25–34 years	15	14	15
	35–44 years	25	25	25
	45–54 years	25	23	27
	55–65 years	20	20	19
	> 65 years	14	16	13
HH head gender (male=1)			0.96	0.99
HH head education category (%)				
	No formal education	82	82	82
	Primary education	10	12	9
	Secondary education	6	5	8
	Higher education	2	1	2
Household size		11	10	10
Dependency ratio		1.14	1.13	1.15
Social network (1=yes)		0.33	0.31	0.37
Agriculture land owned (ha)		2.36	2.36	2.36
Income diversification (%)				
	Agriculture (crop)	0.65	0.69	0.61
	Agriculture (livestock)	0.23	0.17	0.3
	Off-farm	0.04	0.06	0.02
	Self-employed	0.02	0.01	0.02
	Natural resources (firewood)	0.02	0.02	0.02

Source: *Own calculation based on household survey 2013-2016: NB: HH, household.*

In Table 4, we report the knowledge scores of respondents. We found that participants significantly increased their knowledge scores (28% points) in 2016 compared to non-participants. The knowledge score grades the respondent's knowledge on causes of AAT, transmission, prevention and treatment. Similarly, practice score which is a total score improved practices adopted by respondent to manage AAT, ticks, worms and other diseases increased for participants by 11%. These results suggest that TRYRAC intervention is positively correlated with increased knowledge and improved disease management.

Table 4: Knowledge and practices score

Score variable	2013			2016		
	Treated	Control	Difference (t-test)	Treated	Control	Difference (t-test)
Knowledge score (AAT)	9.12	8.8	0.003	37	12.5	28***
Practices score (AAT, ticks & worms)	14.15	13.51	0.01	29	18	11***

Source: *Own calculation based on household surveys 2013 and 2016*

In Table 5, we compare welfare outcomes of participant and nonparticipant households before and after TRYRAC intervention. Focusing on the baseline year first, we do not find significant differences. We however, found significant differences in the period after in welfare outcomes. Although non-participating households reported increase consumption per capita (4% points) from baseline, the net increase for participants was significantly higher (28% points) in the period after intervention.

Table 5: Comparison of welfare outcomes by treatment status

Variable	Pooled 2013	Treated	Control	Pooled 2016	Treated	Control
Income per capita PPP $	772.55 (936.74)	845.73 (945.61)	704.16 (925.19)	691.92 (726.41)	735.70 (708)	651 (742.41)
Consumption per capita PPP $	1004.68 (770.78)	1043.66 (764.05)	968.27 (776.91)	1260.10 (1533.34)	1442.87 (126.04)	1089.31 (1149.42)
Total output value PPP$	37.37 (61.75)	37.56 (65.17)	37.20 (58.54)	125.36 (345)	159.75 (405.40)	91.61 (269.70)
proportion of poor HH (< US$ 1.90/day)	0.62	0.59	0.64	0.66	0.61	0.7
Observations	**443**	**214**	**229**	**443**	**214**	**229**

Source: *Own calculation based on household surveys 2013 and 2016, NB: HH, household, PPP, Purchasing power parity; standard deviations in brackets*

Similarly, both groups recorded an increase in the total net income from cattle output (milk income, traction and transportation) in the period after interventions. However, like consumption, the figures for participating households was significantly higher (PPP$120) than non-participants (PPP$54). One significant point worth pointing out in Table 5 is that all households recorded a drop in income in 2016. This drop was however much pronounced for nonparticipants compared to participants. One possible explanation is that livestock of participating households were resilient because of improved management practices which increased the coping mechanism in handling the income shortfall because of the role of livestock in household income. The implication of this result is that the interventions have strengthened participants' productive assets.

Finally, Table 6 presents the different poverty indices and vulnerability. We found that approximately 41% (39%) of our sampled respondents were living below the poverty line in 2013 (2016). In terms of the different participation status the poverty headcount was 39% (32%) a decrease of 7% points for participants and 44% (43%) a drop of 1% point of non-participants in 2013 (2016). We further found that the poverty gap decreased by 1% among participants while increasing by 3% for non-participants in the period 2013–2016 although the average for the pooled sample was stable. In terms of vulnerability to poverty, we found that although around 30% of all respondents were vulnerable the figure dropped for the participants by 2% points whiles it increased for by a 1% point in 2016. Casual look at these results show three important inferences: First, TRYRAC participants are less poor compared to non-participants in the period after the intervention. Second, there is an overall decrease in poverty between 2013 and 2016 in the total sample. One could possibly argue that this as an indication that the TRYRAC intervention had spill–over effects. Third, TRYRAC interventions could have an impact in reducing the vulnerability of respondents to poverty.

Table 6: Poverty measures by treatment status

	2013			2016		
Poverty measure	**Pooled**	**Treated**	**Control**	**Pooled**	**Treated**	**Control**
Headcount (%)	0.41	0.39	0.44	0.39	0.32	0.43
Poverty gap (%)	0.17	0.16	0.15	0.17	0.15	0.18
Poverty severity (%)	0.78	0.73	0.82	0.96	0.90	0.10
Vulnerability (%)	0.28	0.29	0.26	0.28	0.27	0.28

Source: *Own calculation based on household survey 2013 and 2016*
NB: Calculation of indices based on the US$ 1.90 PPP

The unconditional summary statistics presented above suggest that the TRYRAC intervention improved participants' knowledge, practices and welfare outcomes compared to non-participants. However, these could be driven by other exogenous factors because program participation is likely to be endogenous. In the next section we present the results of the multivariate econometric estimation strategies to net–out the impact of TRYRAC controlling for different estimation concerns as discussed in the methods section.

5. Results and discussion

The impact of TRYRAC's intervention is analyzed in three steps. First, we examine if TRYRAC's disease control interventions improved cattle farmers' knowledge. Second, we investigate if improved knowledge enhances adoption of improved disease control practices.

Third, we investigate the impact interventions on farm households' welfare measured as consumption per capita, poverty headcount and vulnerability to poverty.

5.1. Impact of interventions on farmers' knowledge and practices

Table 7 shows ATTs on knowledge and practices for the different estimation strategies discussed. Columns 1 and 2 show the OLS estimates of the difference in difference estimates with and without household and village fixed effects respectively. Columns 3 and 4 present the fixed-effects OLS results, while the fixed effects instrumental variable estimates are presented in column 5.

Our results generally show a significant positive impact of TRYRAC interventions on knowledge scores and practice adoption of participating households across all specifications. Specifically, the results from Table 7 show that TRYRAC intervention improved the knowledge and awareness of the AAT of participating households by about 30%. The impact coefficients do not significantly differ when we control for household and village fixed effects in column 2, an indication that the correlation between treatment and covariates is low. The FE results in columns 3 and 4 also shows an increase in knowledge score about 31% for the treated after controlling for household's time varying covariates. IV-FE returns similar results like DD and FE estimates. These findings are similar to the results of Liebenehm et al. (2011) who report knowledge increases for cattle farmers in Mali and Burkina Faso after veterinary interventions were introduced.

In the next step, we investigate whether farmers apply improved knowledge. We estimate the effect of knowledge score on improved practices that households adopted for AAT management (Table 7). We find that farmers who had higher knowledge score also adopted more improved practices (between 10% and 12% or 3 additional practices). These results indicate that the cattle of participating households are more likely to be healthier because of low disease incidence or tick and worm infestation. To test this assumption we investigate impact of TRYRAC interventions on AAT prevalence. We found that AAT incidence had gone down for both groups however the margin of drop is significantly bigger in herds of participating (6 animals) compared to non-participants (2 animals) households. On average, the number of animals reported sick over the period dropped by 3 animals for the intervention households compared to control households (Table 7). This modest reduction could be explained by the free–rider effect of non-participants herds causing reinvasion and coinfections. This is because cattle are kept in the open range system thus could cause both positive and negative spill-over effects. For example, improved disease management practices may also lead to a reduction in tsetse population and disease prevalence, which would be a benefit for non-participating households.

Improved animal health is expected to result in higher productivity and in savings in the costs of external inputs. We thus investigate whether the interventions has had any impact on veterinary inputs costs such as trypanocide, insecticides and deworming drugs. Table 7 shows that TRYRAC reduced veterinary input expenditures by approximately 1,950 CFAF to 3,000 CFAF depending on the estimation regime, i.e., about US$3 – 5.5 (per annum per cattle head). In consideration of an average herd size of 9 cattle, this amount translates to US$27–50 of savings per annum.

5.2. Impact of interventions on cattle productivity and consumption

Table 8 presents the results for cattle productivity and consumption per capita. In terms of cattle productivity, we found that improved cattle health has resulted in higher productivity resulting in higher net income from cattle output such as milk, traction and manure. Net income from cattle production of participants on average increased between 84% and 95% in comparison to nonparticipants (Table 8). This result indicates that with good management practices, cattle contribution to household income could double from the current figures. We found a significant positive impact of TRYRAC interventions on increasing consumption per capita for participating households which remains significant across all estimators. Our results show that treated households are able to improve their consumption by approximately PPP US$ 250 to PPP US$290 per annum. Given the significant role of cattle in household income (Table 3), it is not surprising that improved cattle health translates to higher consumption expenditure.

Table 7: Impact of TRYRAC on knowledge, practices, veterinary and disease prevalence

Outcome Variable	Basic OLS DID (1)	Full MLS DID (2)	Basic FE (3)	Full MLS FE (4)	FE IV (5)
Knowledge score	0.307***	0.306***	0.307***	0.307***	0.307***
	(0.0185)	(0.0181)	(0.0185)	(0.0187)	(0.0187)
Practices score	3.782***	0.435	1.120*	1.159*	1.108*
	(0.653)	(0.695)	(0.654)	(0.662)	(0.657)
Veterinary input cost	-1,954**	-2,142**	-1,954**	-3,062**	-3,062**
	(945.6)	(1,082)	(943.8)	(1,222)	(1,245)
AAT Prevalence	-2.885***	-2.917***	-2.885***	-2.832***	-2.832***
	(0.593)	(0.596)	(0.581)	(0.575)	(0.575)
Controls	**No**	**Yes**	**No**	**Yes**	**Yes**
N	**886**	**886**	**886**	**886**	**886**

*Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; standard deviations in brackets; AES adult equivalent scale; PPP; Purchasing power parity: Controls: age, age-sq, household size, dependency ratio, education of household head, social network participation, farm size, herd size*

***Source:** Own calculation based on household survey 2013 and 2016*

5.3. Impact on poverty and vulnerability

The impact of interventions on poverty and vulnerability is presented in Table 9[4]. In column 1, we report the impact of the interventions on poverty headcount. Our results show that TRYRAC significantly reduced the poverty head count by about 11% points. This result is may be explained by the extra savings because of reduced veterinary expenditure and improved income streams of households. Another reason could be that households are able to cultivate their land in a timely manner resulting in improved crop productivity.

In column 2 we report the impact of TRYRAC on vulnerability to poverty. Our findings show that participating households were 8% less likely to be vulnerable to future poverty compared to non-participants. This could also be because of stable crop production and income generating streams as a result of enhanced cattle productivity. This means that participating households would be able to cope with shocks that disrupt future consumption.

[4] The FGLS procedure predicting the future log–consumption and consumption variance is not reported

Table 8: Impact of TRYRAC on household welfare

Outcome Variable	Basic OLS DID (1)	Full MLS DID (2)	Basic FE (3)	Full MLS FE (4)	FE IV (5)
Output PPP US$	1.843***	1.647**	1.843***	1.959**	1.959***
	(0.628)	(0.714)	(0.603)	(0.772)	(0.76)
Consumption per capita p.a. (AES) (PPP US$)	278.2*	289.7*	278.2*	252.8*	252.8*
	(162.4)	(158.2)	(150.3)	(151)	(151.1)
Controls	**No**	**Yes**	**No**	**Yes**	**Yes**
N	**886**	**886**	**886**	**886**	**886**

*Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; standard deviations in brackets; AES adult equivalent scale; PPP; Purchasing power parity: Controls: age, age-sq, household size, dependency ratio, education of household head, social network participation, farm size, herd size*

Source: *Own calculation based on household survey 2013 and 2016.*

Table 9~~10~~: Impact of Tryrac on poverty head count and vulnerability to poverty

	Poverty headcount		Vulnerability	
	Coefficient (1)	Robust standard error (2)	Coefficient (3)	Robust standard error (4)
TRYRAC (Participation)	-0.118*	0.0638	-0.0897**	0.0395
Year	-0.036	0.0804	-0.00819	0.057
Age	-0.023	0.0163	-0.0198**	0.00801
Age2	0.000206	0.000152	0.000172**	0.0000744
HH Size	0.0495**	0.0219	0.0613***	0.0152
HH size square	-0.000405	0.000783	-0.00062	0.000467
Married (1=yes)	-0.114**	0.0568	0.0172	0.0359
Polygamous (1=yes)	0.188*	0.098	-0.404***	0.0871
Farmland (log)	-0.150**	0.0589	-0.221***	0.0411
Farmland square (log)	0.0374	0.0268	0.0432***	0.0142
Dependency ratio	-0.0103	0.0343	-0.0329	0.0223
Formal education (1=yes)	-0.0252	0.0639	-0.0950**	0.0369
Owns plough (1=yes)	-0.0659	0.0517	-0.0893**	0.037
Owns motor (1=yes)	-0.0641	0.0625	-0.221***	0.0387
Owns mobile (1=yes)	-0.066	0.0521	-0.153***	0.0344
Agric association (1=yes)	-0.00229	0.0682	-0.0521	0.0415
Leader association (1=yes)	0.0982	0.0723	-0.000915	0.0555
Crop shock (1=yes)	-0.084	0.0775	-0.0243	0.0519
Illness shock (1=yes)	0.0305	0.049	-0.0145	0.0311
Income shock (1=yes)	0.089	0.0823	0.0405	0.0551
Livestock shock (1=yes)	-0.155**	0.0721	-0.0297	0.0518
Covariate shocks (1=yes)	-0.032	0.146	-0.059	0.077
Constant	0.918**	0.438	0.754***	0.224
sigma_u	0.360		0.261	
sigma_e	0.451		0.291	
rho	0.389		0.445	
F(21, 422)	2.87		7.20	
Prob > F	0.000		0.000	
Observations	886		886	
R^2	0.11		0.306	

*Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

Source: *Own calculation based on household survey 2013-2016*

6. Conclusions and policy implications

The role of livestock in improving the livelihoods of rural remains critical in rural SSA where credit, formal employment and other factor markets are highly imperfect or absent. Cattle as the main livestock has the potential for improving household livelihoods, reducing poverty and reducing consumption volatility that tends to make households vulnerable to poverty. However, negative effects of livestock diseases such as AAT augmented by the resistance to trypanocides and unsustainable disease control measures practiced livestock holders have dwarfed this potential.

Using a balanced household panel data set from Togo, this paper investigated the impact of veterinary interventions launched within the scope of the EU funded TRYRAC project on smallholder households' welfare in SSA. We discuss the linkage between knowledge gain and adoption of livestock husbandry practice for disease prevention and management. We employed different econometric estimations strategies to control for selection bias and program endogeneity that are likely to arise as a result of the non-randomization of the TRYRAC interventions.

Our results show a positive impact of the TRYRAC interventions on improving knowledge which remains significant and robust across all model specifications. We found that participating households had a rise in knowledge scores of 30% compared with non-participants. For every 10% in knowledge increase, participants adopted 2 more improved cattle husbandry practices. We also found that adoption of improved practices in resulted in a drop in AAT infections. Fewer AAT infections lead to savings in veterinary input cost of US$3 – 5.5 per cattle head p.a. which translates to an annual saving of approximately US$27–50 per herd for the average herd size in our sample in Northern Togo. In terms of household welfare, we found an increase in consumption per capita of between PPP$ 250 and PPP$ 290, reducing poverty and vulnerability by 11% and 8% respectively. Thus, the overall conclusion of this study points to the important role of livestock interventions to improving rural livelihoods in SSA.

The following policy recommendations are derived from the conclusions. First the case of TRYRAC shows the effectivity of well-planned extension programs that includes radio, market and village outreach programs to increase dissemination and raise knowledge of the target group. To scale up technology adoption there should be increased farmer and local partner participation in the technology dissemination chain. Second, ownership of farm implements like the animal drawn plough should be encouraged among cattle farmers by removing the bottlenecks and the bureaucracy in the access to credit. Farmers could also be assisted to form cooperatives to operate animal drawn machinery pool. This would increase household income and improve crop production important determinants of rural poverty and vulnerability.

References

Abadie, A. (2005): Semiparametric difference-in-differences estimators, *Review of Economic Studies*, 72.

Abadie, A., Angrist, J. D. and Imbens, G. W. (2002): Instrumental Variables Estimates of the Effect of Subsidized Training on the Quantiles of Trainee Earnings." *Econometrica,* 70 (1), 91–117.

Affognon, H., (2007): Economic analysis of trypanocide use in villages under risk of drug resistance in West Africa, PhD dissertation, Leibniz Universitaet Hannover Germany.

Amare, M., S., Asfaw, and B. Shiferaw (2012): Welfare impacts of maize-pigeon pea intensification in Tanzania. *Agricultural Economics,* 43(1), 27–43.

Asfaw, S., Kassie, M., Simtowe, F. and Lipper, L. (2012): Poverty reduction effects of agricultural technology adoption: a micro-evidence from rural Tanzania. *Journal of Development Studies*, 48 (9), 1288–1305.

Ashenfelter, O. (1978): Estimating the Effect of Training Programs on Earnings, *The Review of Economic and Statistics,* 60, (1), 47–57.

Bertrand, M., Duflo, E. and Mullainathan, S. (2004): "How much should we trust differences-in-differences Estimates?" *Quarterly Journal of Economics*, 119 (1), 249–275, MIT Press,

Budd, L. T. (1999): DFID-Funded Tsetse and Trypanosomiasis Research and Development since 1980, Vol 2, Department for International Development (DFID), London, UK.

Cecchi, G. and Mattioli, R. C. (2009): Global geospatial datasets for African trypanosomiasis management: A review', Geospatial Datasets and Analyses for an Environmental Approach to African Trypanosomiasis. Rome, Italy: FAO.

Clausen, P. H., Bauer, B., Zessin, K. H., Diall, O., Bocoum, Z., Sidibe, I., Affognon, H., Waibel, H., Grace, D. and Randolph, T. (2010): "Preventing and containing trypanocide resistance in the cotton zone of West Africa", *Transboundary and Emerging Diseases* 57 (1–2), 28–32.

Davis, K., Nkonya, E., Kato, E. Mekonnen, D. A., Odendo M., Miiro, R. and Nkuba, J. (2012): Impact of Farmer Field Schools on Agricultural Productivity and Poverty in East Africa, *World Development,* 40 (2), 402–413

Duflo, E., Glennerster, R. and Kremer, M. (2006): Using randomization in development economics research: A toolkit. Working Paper 138. Cambridge: Harvard University Center for International Development.

Fafchamps, M., Udry, C., and Czukas, K. (1998): Drought and saving in West Africa: are livestock a buffer stock? *Journal of Development Economics*, 55 (2), 273–305.

Foster, J., Greer, J., and Thorbecke, E. (1984): A class of decomposable poverty measures. *Econometrica*, 52 (3), 761–766.

Glewwe, P., and Miguel E. A. (2008): The impact of child health and nutrition on education in less developed countries. In Schultz T. P., Strauss J. (Eds.), *Handbook of development economics* 4: 3561–3606). Amsterdam, Netherlands: Elsevier.

Grace, D., Randolph, T., Affognon, H., Dramane, D., Diall, O., Clausen, P-H. (2009): Characterisation and validation of farmers' knowledge and practice of cattle trypanosomosis management in the cotton zone of West Africa. *Acta tropica*, 111 (2), 127–143.

Hoddinott, J. and Quisumbing, A. R. (2003): Data Sources for Microeconometric Risk and Vulnerability Assessments, Social Protection Discussion Paper series, No. 0323 World Bank, Washington DC.

Imbens, G. M. and Wooldridge, J. M. (2008): Recent developments in the econometrics of program evaluation. Working Paper 14251. Cambridge, MA, U.S.A.: National Bureau of Economic Research.

Imbens, G. W. and Angrist, J. D. (1994): "Identification and estimation of local average treatment effects". *Econometrica*, 62: 467–75.

IMF. (2014): International Monetary Fund Country Report for Togo, No. 14/224 "Strategy for boosting growth and promoting employment". Washington DC. http://www.imf.org.

Kassie, M., B. Shiferaw and G. Muricho (2011): Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda, *World Development*, 39 (10), 1784–1795.

Kazianga, H., and Udry, C. (2006): Consumption smoothing? Livestock, insurance and drought in Burkina Faso, *Journal of Development Economics* 79: 413–446.

Khandker, S. R., Koolwal, G. B. and Samad, H. A. (2010): Handbook on Impact Evaluation: Quantitative Methods and Practices. *The World Bank, Washington, DC*.

Liebenehm, S., Affognon, H. and Waibel, H. (2011a): Collective livestock research for sustainable disease management in Mali and Burkina Faso. *International Journal of Agricultural Sustainability*, 9 (1), 212 – 221

Liebenehm, S., Affognon, H. and Waibel, H. (2011b): Impact Assessment of Livestock Research and Development in West Africa: A Propensity Score Matching Approach. *Quarterly Journal of International Agriculture*, 50 (3): 253–266

Mason, N. M., Wineman, A., Kirimi, L. and Mather, D. (2017): The effects of Kenya's 'smarter' input subsidy program on smallholder behavior and incomes: Do different quasi-experimental approaches lead to the same conclusions? *Journal of Agricultural Economics* 68: 45–69.

McKenzie, D., Stillman, S. and Gibson, J. (2010): "How important is selection? Experimental vs. Non-experimental measures of the income gains from migration". *Journal of the European Economic Association,* 8, 913–945

Mendola M, (2007): "Agricultural technology adoption and poverty reduction: A propensity score matching analysis for rural Bangladesh". *Food Policy* 32: 372–93.

O'Neill, S., Kreif, N., Grieve, R. and Sekhon, J. S. (2016): Estimating causal effects: considering three alternatives to difference-in-differences estimation. *Health Services Research and Outcomes Methodology,* 16, 1–21.

Perry, B. D., Randolph, T. F., McDermott, J. J., Sones, K. R. and Thornton, P. K. (2002): Investing in Animal Health Research to Alleviate Poverty. ILRI, Nairobi, Kenya.

Pica-Ciamarra U, Tasciotti L, Otte, J. and Zezza, A. (2015): Livestock in the household economy: cross-country evidence from microeconomic data. *Development Policy Review* 33, 61–81.

Ravallion, M., Chen, S. and Sangraula, P. (2007): New Evidence on the Urbanization of Global Poverty. *Population and Development Review*, 33 (4), 667–701

Rosenbaum P. R. and Rubin D. B. (1983): "The central role of the propensity score in observational studies for causal effects". *Biometrika,* 70, 41–55.

Shiferaw, B., Kassie, M., Jaleta, M., and Yirga, C. (2014): Adoption of improved wheat varieties and impacts on household food security in Ethiopia. *Food Policy*, 44, 272–284.

Simarro, P. P., G., Cecchi, M., Paone, J. R., Franco, A., Diarra, J. A., Ruiz, E. M., Fèvre, F., Courtin, R. C. Mattioli, and J. G. Jannin, (2010): The Atlas of human African trypanosomiasis: A contribution to global mapping of neglected tropical diseases. *International Journal of Health Geography,* 9, 57.

Stuart, E. A., Huskamp, H. A., Duckworth, D., Simmons, J., Song, Z., Chernew, M. E. and Barry, C. L. (2014): Using propensity scores in difference-in-differences models to estimate the effects of a policy change. *Health Services Outcomes Research Methodology,* 14 (4), 166–182.

Swallow, B. M. (2000). Impacts of Trypanosomiasis on African Agriculture. FAO, Rome, Italy.

Tchamdja, E., Kulo, A. E., Akoda, K., Teko-Agbo, A., Assoumy, A. M., Niang, … and Delespaux, V. (2016): Drug quality analysis through high performance liquid chromatography of isometamidium chloride hydrochloride and diminazene diaceturate purchased from official and unofficial sources in Northern Togo. *Preventive Veterinary Medicine,*126, 151–158

Tornimbene, B., Chhim, V., Sorn, S., Drew, T. W. and guitian J. (2014): Knowledge, attitudes and practices of Cambodian swineproducers in relation to porcine reproductive and respiratorysyndrome (PRRS). *Preventive veterinary medicine*, 116, 252–267

WDI, (2014): Washington. World Bank, DC. http://dx.doi.org/10.1596/978-1-4648-0163-1.

Wen, H., Hockenberry, J. M. and Cummins, J. R. (2015): The effect of medical marijuana laws on adolescent and adult use of marijuana, alcohol, and other substances. *Journal of health economics*, 42, 64–80

WHO, (1987): The Rational Use of Drugs, Report of the Conference of Experts, Nairobi 25–29 November 1985. World Health Organization, Geneva.

Wooldridge, J. M. (2010): "Econometric analysis of cross section and panel data. The MiT press.