INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty
Supported by the CGIAR

ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

ETHIOPIAN DEVELOPMENT RESEARCH INSTITUTE

Integrating livestock in the CAADP framework: Policy analysis using a dynamic computable general equilibrium model for Ethiopia

Ayele Gelan, Ermias Engida, A. Stefano Caria, and Joseph Karugia

Development Strategy and Governance Division, International Food Policy Research Institute – Ethiopia Strategy Support Program II, Ethiopia

Ethiopia Strategy Support Program II (ESSP II)

ESSP II Working Paper 34

January 2012

IFPRI-ADDIS ABABA
P.O. Box 5689
Addis Ababa, Ethiopia
Tel: +251-11-646-2921
Fax: +251-11-646-2318
E-mail: ifpri-addis@cgiar.org
http://essp.ifpri.info/

IFPRI HEADQUARTERS
International Food Policy Research Institute
2033 K Street, NW • Washington, DC 20006-1002
USA
Tel: +1-202-862-5600
Skype: IFPRIhomeoffice
Fax: +1-202-467-4439
E-mail: ifpri@cgiar.org
http://www.ifpri.org

THE ETHIOPIA STRATEGY SUPPORT PROGRAM II (ESSP II) WORKING PAPERS

ABOUT ESSP II

The Ethiopia Strategy Support Program II is an initiative to strengthen evidence-based policymaking in Ethiopia in the areas of rural and agricultural development. Facilitated by the International Food Policy Research Institute (IFPRI), ESSP II works closely with the government of Ethiopia, the Ethiopian Development Research Institute (EDRI), and other development partners to provide information relevant to the design and implementation of Ethiopia's agricultural and rural development strategies. For more information, see http://www.ifpri.org/book-757/ourwork/program/ethiopia-strategy-support-program or http://essp.ifpri.info/ or http://www.edri.org.et/.

ABOUT THESE WORKING PAPERS

The Ethiopia Strategy Support Program II (ESSP II) Working Papers contain preliminary material and research results from IFPRI and/or its partners in Ethiopia. The papers are not subject to a formal peer review. They are circulated in order to stimulate discussion and critical comment. The opinions are those of the authors and do not necessarily reflect those of their home institutions or supporting organizations.

About the Author(s)

Ermias Engida: Research Officer, Ethiopia Strategy Support Program II, Ethiopian Development Research Institute (EDRI)

Ayele Gelan: Economist, International Livestock Research Institute (ILRI)

A. Stefano Caria: Economist, Disaster Prevention and Preparedness Commission (DPPC)

Joseph Karugia: ReSAKSS-ECA / International Livestock Research Institute (ILRI)

Integrating livestock in the CAADP framework: Policy analysis using a dynamic computable general equilibrium model for Ethiopia

Ayele Gelan, Ermias Engida, A. Stefano Caria,
and Joseph Karugia

Development Strategy and Governance Division, International Food Policy Research Institute – Ethiopia Strategy Support Program II, Ethiopia

Table of Contents

List of Tables

List of Figures

List of Appendices

Abstract

Researchers and policymakers increasingly recognize that the livestock sector supports the livelihoods of a large proportion of rural households in Africa and may have an important role to play in rural poverty reduction strategies. In order to develop this insight, economywide models should capture both the biological, dynamic relationships between the stocks and flows of livestock and the economic linkages between the sector and the rest of the economy. We extend an existing dynamic recursive general equilibrium model for the Ethiopian economy to better model the livestock sector. A separate herd dynamics module enables us to specify stock–flow relationship, distinguishing between the capital role of livestock and the flow of livestock products. We also improve the underlying system of economic accounts to better capture draft power and breeding stocks. We use this model to simulate separate, realistic Total Factor Productivity (TFP) shocks to three agricultural subsectors—cereals, cash crops, and livestock—and compare them with a baseline scenario replicating Ethiopia's 1998 to 2007 productivity trends. In doing so, we follow Dorosh and Thurlow (2009) who have examined CAADP productivity scenarios.

The results reveal the important role of the livestock sector in increasing various measures of GDP and combating food insecurity. Agricultural GDP and overall GDP growth levels achieved in the livestock TFP shock scenario are very similar to those achieved in the cereal TFP shock scenario, unlike what was previously thought. Importantly, as factors are dynamically re-allocated between agricultural activities, our analysis highlights the inefficiency of strategies focusing on cereal sector development alone. Moreover, livestock sector productivity growth leads to greater factor income growth—particularly labor income—than in the other simulations. Labor is the predominant asset of poor households and hence large income gains and food consumption growth are realized under the livestock-led scenario.

1. Introduction

The livestock sector supports the livelihoods of a large proportion of rural households in Ethiopia. It accounts for about one-third of agricultural GDP, approximately the same as total cereals, and 14 percent of overall GDP in 2005. Livestock products, including live animals, meat, and leather goods, are a major source of foreign exchange—about birr 1.08 billion or 6.4 percent of total exports. Meat, eggs, dairy, and other livestock products together account for about 12 percent of the value of total household consumption. Additionally, farmers in most regions in Ethiopia rely heavily on oxen draft power to till the land for crop production. The critical role livestock plays in the Ethiopian economy means that negative shocks to this sector can have adverse effects on the livelihoods of millions of households and on the performance of the wider economy. Conversely, accelerated growth in the sector has the potential to stimulate economic growth and reduce poverty significantly.

In spite of the critical role the livestock sector plays in the country's economy, the sector has not received the policy-level priority it deserves.[1] This is partly explained by a lack of in-depth analytical research and policy tools that would inform decisionmaking and priority setting at sectoral, regional, or national levels. There has been a substantial amount of microeconomic or partial equilibrium analysis on livestock production in Ethiopia, particularly for crop–livestock systems in the Ethiopian highlands. However, partial equilibrium analysis cannot show feedback mechanisms between the livestock sector and the rest of the economy, since the rest of the economy is considered as exogenous. What seem to be missing are systematic studies using multisectoral and economywide modeling approaches that will reveal interactions between the livestock sector and the rest of the economy. In this regard, existing computable general equilibrium models applied to the Ethiopian and other less developed economies have serious shortcomings in that they lack the dynamics required to capture the unique biological processes, stock–flow relationships, and heterogeneities of the livestock sector. Furthermore, such models rarely acknowledge in full the important economic linkages that arise in mixed farming systems between livestock development and other agricultural activities.

This study sets out to fill this gap in livestock sector policy analysis in Ethiopia and in livestock-based livelihood systems. This is done by extending an existing dynamic recursive model developed for the Ethiopian economy (Dorosh and Thurlow 2009) to simulate different agricultural growth scenarios under the Comprehensive African Agricultural Development Programme (CAADP).[2] Using realistic baseline and accelerated sectoral productivity growth trends, this study compares accelerated growth in the livestock sector to accelerated growth in the cereal and the cash crop sectors. Differences in outcomes along efficiency and welfare dimensions are then explored.

The contribution of the study is twofold. First, it develops a herd dynamics and productivity model which is then coupled with the dynamic recursive computable general equilibrium model calibrated on Ethiopian data. Further modifications to the economywide model were also implemented to strengthen its biophysical basis, such as land use patterns and stocks of capital in addition to those related to the livestock capital. In this sense, the study provides a methodological contribution to general equilibrium modeling of livestock dynamics. Second, novel findings related to efficiency and equity outcomes are presented. As the

[1] The Ministry of Agriculture's 2010-2020 Policy and Investment framework, for example, recognizes that "there is a lack of focus in livestock development policy" (Ministry of Agriculture 2010 p.9) and calls for "an enhanced livestock subsector strategy […] to address key constraints to livestock productivity" (Ministry of Agriculture 2010 p.11)

[2] The CAADP aims at improving food security, nutrition, and increasing incomes in Africa's largely farming-based economies, raising agricultural productivity by at least 6 percent per year and increasing public investment in agriculture to 10 percent of national budgets per year (NEPAD-CAADP 2010)

simulated realistic supply-side shocks outstrip growth in demand, factors of production are reallocated from sectors of fast productivity growth to less dynamic sectors. Scenarios where productivity growth is more evenly distributed across agricultural activities ensure the efficiency of this reallocation process. In Ethiopia, where policy efforts have traditionally been focused on cereal and cash crop development, this means paying more attention to productivity growth for livestock. Moreover, through factor reallocation and linkages to the crop sector, accelerated livestock growth improves the returns to agricultural labor the most. Contrary to what has often been argued in the past, development of the livestock sector has some marked pro-poor features.

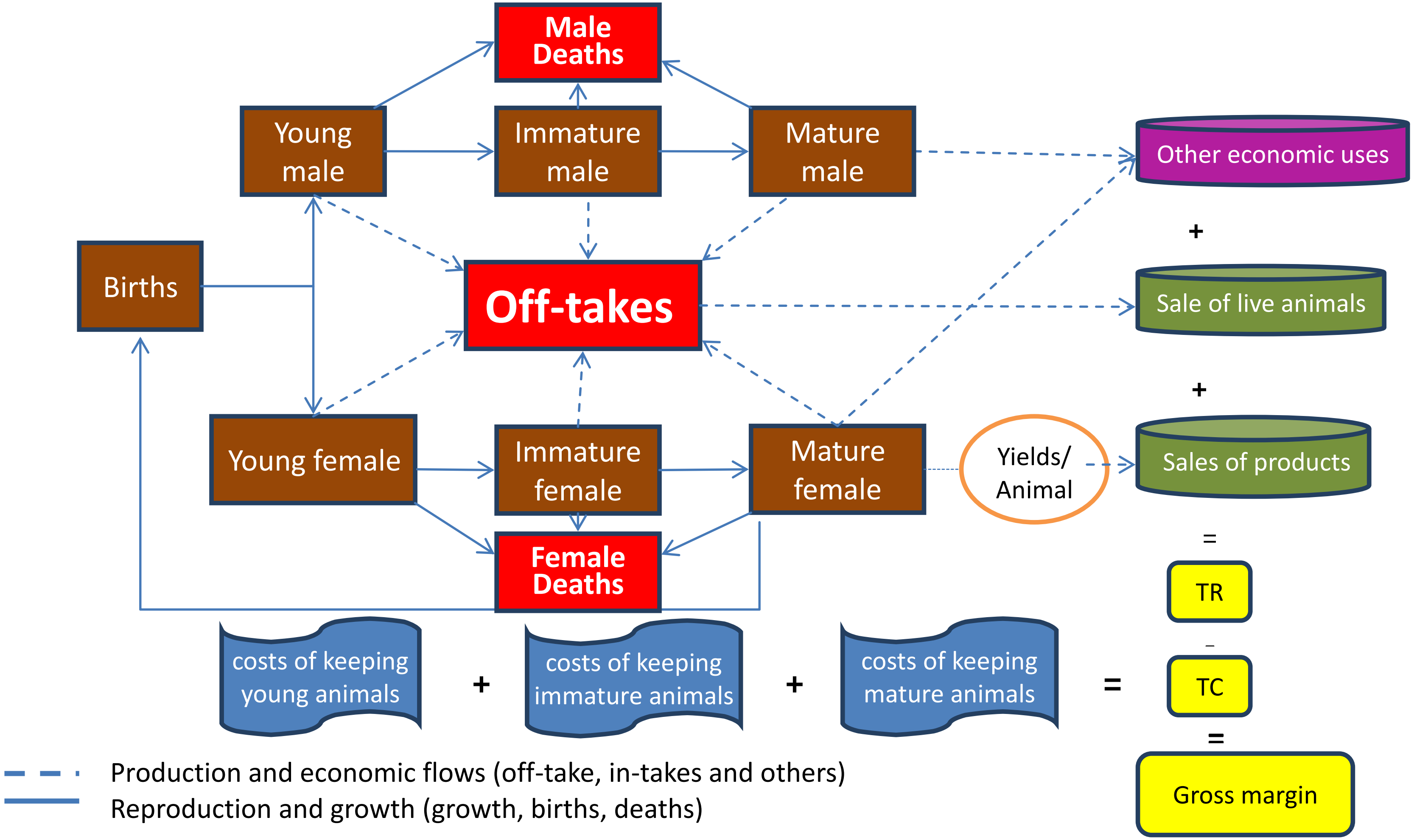
The remaining part of this study is structured as follows. The next section discusses conceptual frameworks that inform the development of the herd dynamic and productivity model. This is followed by a brief description of the dynamic recursive model, which was modified and then coupled with the livestock sector module. The subsequent sections will discuss data sources, simulation scenarios, model results, and concluding remarks, in that order.

2. A conceptual framework for a herd dynamics model

A schematic representation of a generic herd dynamics and productivity model is displayed in Figure 2.1 below. It is generic in the sense that most livestock types can be represented in the stock–flow diagram. The dynamics of the stocks are represented by the solid lines related to adjustment to stocks, changes in the number of livestock in different stages and ages. For instance, mature females give birth to young ones, which are then categorized into male and female counterparts. Each sex category will pass through different stages—young, immature, and then mature. The proportion that passes to the next stage depends on survival rates, which in turn are determined by death rates and off-take rates.

Off-takes represent economic flows: sales of live animals from different stages of growth. There are other economic flows depicted in the right hand side of Figure 2.1: livestock products (for example, milk or eggs) and other economic services from the livestock (for example, oxen draft power or transport services by pack animals). The quantity of live animals and livestock products multiplied by their corresponding prices give total revenue from livestock activities. The lower part of the figure shows costs of keeping livestock in different stages of development. Like other sectors, livestock production requires labor, land, and standard capital stock categories such as buildings, machinery, and equipment. The sum of these gives total costs of livestock production activity. The difference between total revenues and total costs yields gross margin of keeping livestock.

Figure 2.1. Schematic representation of herd dynamics and productivity



Source: Author's compilation
Note: TR = Total Revenues; TC = Total Costs

There is a deeper economic logic in the relatively simple diagrammatic exposition of stock–flow relationships displayed in Figure 2.1. It should be noted that in each stage of their growth, the livestock units stay for a relatively long duration. For instance, a typical dairy cow continues to yield milk for over a decade until it is culled due to reductions in productivity at old age. Similarly, during their life time, breeding stocks in the cattle or small ruminants sector give birth to many offspring that are sold year after year as finished stocks or products. This means that livestock units are themselves assets that continue to survive year after year and produce products or accumulate wealth over several years.
Additionally, the sizes and values of the breeding stocks in each stage change through time depending on social, economic, and environmental conditions. These relate to restocking or destocking (analogous to the investment process in other capital stock categories) or appreciation in the value of breeding stocks due to investments in the maintenance of the health and body conditions of the livestock units. The specification of the herd dynamics and productivity module couples the other source of dynamic changes in the livestock sector—that is, the complex biological processes related to births, deaths, and survival rates—with the dynamic economic processes and analyzes them jointly.

A key strategy in integrating a bio-economic livestock sector model is to translate the conceptual framework displayed in Figure 2.1 into a system of equations that constitute a herd dynamics model. The motivation for this lies in the need to establish a vital relationship between stocks (livestock numbers) and flows (livestock products). The herd dynamics sub-model explicitly tracks numbers of animals of various livestock types, including various alternative formulations of livestock investment demand and off-take. In this study, the herd dynamics model tracks stock–flow relationships for five livestock types in the Ethiopian economy: cattle, sheep, goats, camels, and poultry.

3. Model specification and data organisation

3.1. The CGE model

The model used in this study was originally developed by IFPRI, and is commonly referred to in the literature as a standard computable general equilibrium (CGE) model. It is a multipurpose and flexible model that has been widely applied to analysis of various macroeconomic and sectoral policies in many developed countries (Lofgren, Harris, and Robinson 2002).

In the model of the Ethiopian economy used here, twelve representative household groups maximise their incomes by allocating mobile factors across activities. Households are differentiated along urban–rural and poor–nonpoor dimensions and a number of agro-ecological zones. A multi-stage production function aggregates factor inputs into value-added, and then mixes value-added with further intermediate inputs. Aggregation follows constant elasticity of substitution (CES) or Leontieff technologies. Domestically produced output is an imperfect substitute for output that is internationally traded. Again, a CES function determines the degree of substitutability, with separate parameters for the substitution of domestic output with imports, and for that of output consumed domestically with exports.

It is known that CGE model results are sensitive to the choice of such elasticity parameters (Kapushiski and Warr 1999; Diao, Yeldan, and Roe 2009). We thus calibrate our model with trade elasticities borrowed from the GTAP dataset. Cereals apart from wheat and the livestock and poultry categories have low constant elasticities of transformation. This means that a large relative price fall will be necessary to stimulate an increase in exports. Conversely, wheat, dairy, and cash crops show higher elasticities.

On the demand side, a linear demand system is specified and calibrated with income elasticities estimated in recent empirical work on Ethiopia (Tafere, Taffesse, and Tamiru 2010; Tafere and Worku 2011).

A number of closure rules are specified to ensure balance of key macroeconomic accounts. In our simulations, factors are fully employed and mobile across sectors. The nominal wage rate adjusts to balance supply and demand. Furthermore, investment is driven by available savings, which are in turn determined by a fixed marginal propensity to save out of households' income. A floating nominal exchange rate ensures balance in the external account. Lastly, the tax rate is fixed and government savings adjust accordingly.

Dorosh and Thurlow (2009) have reformulated this model and developed a dynamic and recursive version which was used to analyse agricultural growth scenarios for a CAADP background paper for Ethiopia. The model solves for equilibrium in each period. Agents are not forward looking and make their decisions based on static optimization. Investment and exogenous factor growth in a given year determine factor quantities in the following period.

Here we limit our discussion to elements of the model which were modified in the process of conducting this study. The primary novel element is the translation of the herd dynamic model represented in Figure 2.1 into algebraic equations for use in a computer programme in the GAMS (General Algebraic Modeling Systems) language. The remaining methodological elements are discussed in the following sections.

3.2. Collect and organize livestock data

We first compile data on the livestock sector which is comprehensive in its coverage and is consistent with the conceptual structure displayed in Figure 2.1 and the herd dynamics sub-model developed for the study. In order to have the relevant and detailed biological and economic flows at the base year, additional data sets are used.

Appendix Table A.1 shows the number and prices of livestock by type, sex, and stages of growth at different age levels for five agroecological zones (AEZs). Each livestock type is classified into five age groups: very young (vy), young (yn), immature (im), adult (ad), and final stage of their lifespan (fn).

In addition to data displayed in Table A.1, the herd dynamics is implemented by making use of a rich set of additional data obtained from the Central Statistical Authority of Ethiopia. These data included baseline information on the dynamics in the number of each livestock type through births, deaths (by cause), purchase, sales, and gifts (received or given).

3.3. Integrate livestock accounts into the Social Accounting Matrix (SAM)

Dorosh and Thurlow (2009) implemented the previous version of the model by calibrating it with a Social Accounting Matrix (SAM) developed by the Ethiopian Development Research Institute (EDRI), with 2005 as the base year (Ahmed 2009). A SAM is a comprehensive and consistent representation of economic flows in a system of national accounts. The presentation of economic flows in a matrix format enables a concise display of information. Cells under a particular column represent payments (or outgoings from the economic account named in the column heading) and cells against a row account represent receipts (or incomings).

A particular cell in the matrix simultaneously represents a payment from the account in the column heading and a receipt by the account in the row heading. SAM is usually a square and balanced matrix—a square because payments and receipts between any two accounts or groups of accounts have to be accounted for (leaving blank or entering zero if there is no transaction between any two accounts), and balanced because for any account the sum of all payments should be equal to the sum of receipts.

The current study is based on the Ethiopian SAM which has 97 activities, 69 agricultural activities (including livestock), 66 commodities, 26 factors of production (disaggregated into labor, land, livestock, and other capital stock categories), and 16 institutions made up of 14 household types, together with government and enterprise. The SAM also has different tax, saving-investment, inventory, and 'rest of the world' accounts to show the interaction of different economic agents.

We present a condensed version of the Ethiopian SAM in Table 3.1 below. All other accounts are collapsed or aggregated, but the livestock accounts are left with the same level of disaggregation as represented in the SAM implemented in the model. There are five livestock sector accounts represented by LIVS-A (AEZ-*), where LIVS denotes the size of livestock sector, AEZ represents an agroecological zone. For instance, entries against LIVS-A (AEZ-1) refers to the size of livestock sector activities in agroecological zone 1. The five AEZs are described as: humid lowlands with reliable moisture (AEZ-1); moisture-sufficient highlands (AEZ-2); cereals-based, moisture-sufficient highlands (AEZ-3); enset-based, drought-prone highlands (AEZ-4); and pastoralist or arid lowland (AEZ-5).

Table 3.1. A condensed and balanced Social Accounting Matrix for Ethiopia (2005), in million ETB.

	LIVS-A (AEZ-1)	LIVS-A (AEZ-2)	LIVS-A (AEZ-3)	LIVS-A (AEZ-4)	LIVS-A (AEZ-5)	Oagri-A	Nonagri-A	Live animals -C	Poultry -C	Milk -C	Oagri-C	Non-agri –C	Labor	Land	Livestock capital	Other capital	Trans. Costs	Institutions	Savings	Taxes	Imports	**Totals**
LIVS-A (AEZ-1)	0	0	0	0	0	0	0	**114**	**6**	**71**	0	0	0	0	0	0	0	0	0	0	0	**191**
LIVS-A (AEZ-2)	0	0	0	0	0	0	0	**5553**	**173**	**1907**	0	0	0	0	0	0	0	0	0	0	0	**7632**
LIVS-A (AEZ-3)	0	0	0	0	0	0	0	**983**	**25**	**754**	0	0	0	0	0	0	0	0	0	0	0	**1762**
LIVS-A (AEZ-4)	0	0	0	0	0	0	0	**3372**	**124**	**942**	0	0	0	0	0	0	0	0	0	0	0	**4437**
LIVS-A (AEZ-5)	0	0	0	0	0	0	0	**745**	**17**	**3205**	0	0	0	0	0	0	0	0	0	0	0	**3967**
Oagri-A	0	0	0	0	0	0	0	0	0	0	40341	19	0	0	0	0	0	0	0	0	0	**40360**
Nonagri-A	0	0	0	0	0	0	0	0	0	99	234	128620	0	0	0	0	0	0	0	0	0	**128953**
Liveanimals-C	0	0	0	0	0	0	940	0	0	0	0	0	0	0	0	0	0	6496	3000	0	701	**11138**
Poultry-C	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	316	-6	0	27	**369**
Milk-C	0	0	0	0	0	0	430	0	0	0	0	0	0	0	0	0	0	6990	0	0	52	**7473**
Oagri-C	0	0	0	0	0	2791	3244	0	0	0	0	0	0	0	0	0	0	36508	-173	0	6318	**48689**
Non-agri -C	4	164	38	96	86	2144	55109	0	0	0	0	0	0	0	0	0	23098	78130	31295	0	9676	**199840**
Labor	128	5155	1184	2990	2671	26959	21206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**60294**
Land	0	0	0	0	0	7585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**7585**
Livestock capital	**59**	**2313**	**540**	**1352**	**1210**	**880**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**6353**
Other capital	0	0	0	0	0	0	47991	0	0	0	0	0	0	0	0	0	0	0	0	0	453	**48444**
Transaction costs	0	0	0	0	0	0	0	352	19	391	5838	16497	0	0	0	0	0	0	0	0	0	**23098**
Institutions	0	0	0	0	0	0	0	0	0	0	0	0	60294	7585	6353	48229	0	6919	0	14154	19521	**163055**
Savings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23119	3716	0	10998	**37833**
Taxes	0	0	0	0	0	0	0	13	1	37	69	9980	0	0	0	0	0	4054	0	0	0	**14154**
Imports	0	0	0	0	0	0	0	6	5	67	2206	44724	0	0	0	215	0	522	0	0	0	**47745**
Totals	**191**	**7632**	**1762**	**4437**	**3967**	**40360**	**128953**	**11138**	**369**	**7473**	**48689**	**199840**	**60294**	**7585**	**6353**	**48444**	**23098**	**163055**	**37833**	**14154**	**47745**	

Source: Ahmed et al. (2009)

Notes: LIVS = size of livestock sector, AEZ = agroecological zone, Oagri-A = other agricultural activities, Nonagri-A = nonagricultural activities, Liveanimals-C = Sales from live animals (except poultry), Poultry-C = sales from live chicken and eggs; Milk-C = sales from milk and milk products; Oagri-C= sales from other agricultural products; Non-agri-C= sales from nonagricultural products. In 2005, US1.00 ≈ ETB 8.50.

We formulate the livestock sector sub-model and related additional databases in such a way that they are consistent and compatible with the system of accounts in the existing SAM and the dynamic recursive model previously developed. The details of livestock economic accounts (calculated revenues from off-takes of different livestock types and their products) are aggregated into three major groups of accounts which are denoted in Table 3.1 by “live animals-c” (sales of live animals except poultry); “poultry-c” (revenues from sales of live chicken and eggs), and “milk-c” (sales or imputed income from milk from cattle, goats, and camels).

In the context of Table 3.1, combining the activities and commodities, the size of livestock activities in moisture highland Ethiopia, for instance, is calculated as 7.6 billion ETB (marginal totals of row or column heading given as “LIVS-A (AEZ-2)”). This comes from (reading across the row against this account): 5.5 billion sales of live animals, 0.2 billion sales of live chicken and eggs, and 1.9 billion sales of milk and milk products.

As noted earlier, one of the novel features of the current study is the establishment of firm links between stock and flows in the economic accounts. In practice, this means having a biophysical stock account behind the economic flows represented in the SAM. In Table 3.1, the figures displayed in the sub-matrix in bold fonts against the livestock activity accounts come from the livestock module and are reconciled with the economywide model. Although these accounts are condensed into a summary of a five-by-three matrix, a complex relationship leading to this summary is handled in the background within the herd dynamics model. In such a framework, exogenous shocks to the livestock production systems can be traced to the economic flows. Economic shocks that affect equilibrium relationships in the system of national accounts can also be traced back to the biophysical level. Specifying stock–flow linkages in this manner has rarely been implemented in economywide CGE models.

The other novel element in this study is the recognition of livestock capital as a factor of production in production sectors (see the row heading livestock capital in Table 3.1). The original SAM has detailed presentation of the value addition of all factors of production and their contribution to household income. In many economywide models, livestock capital is simply lumped together with other capital stock categories. Thus, in the Ethiopian SAM it was subsumed under factor payments to land. However, in economies like Ethiopia, livestock capital plays a vital role in other agricultural activities, and crop production in particular. After examining data from various sources, official statistics, and reviewing the literature, Behnke (2010) provided an interesting summary of findings about the role of oxen draft power in the Ethiopian economy. According to this source, about 80 percent of Ethiopian farmers use animal traction to plough their fields. This study uses estimates from Behnke (2010, p. 26) in order to split livestock capital from land capital in the total factor payment by the crop and livestock sectors. Accordingly, sectoral gross value-added attributable to livestock capital is estimated as 6.4 billion ETB. This is further divided into livestock capital used in the livestock sector itself and oxen draft power employed in the crop production (see intersection between row “livestock capital” and column “Oagri-A”, which denotes other agricultural activities).

4. Simulation results

4.1. Simulation scenarios

The simulation strategy used in this study closely followed scenarios implemented in Dorosh and Thurlow (2009) who simulated Total Factor Productivity (TFP) shocks to three agricultural subsectors. These were cereals (including enset, a perennial plant resembling banana and constituting a major staple in the Central and Southern Ethiopia), cash crops (including pulses), and livestock. In the base year (2005), the three major subsectors of agriculture had the following shares in total agricultural GDP: cereals (38 percent), livestock (33 percent), and cash crops (29 percent). Dorosh and Thurlow (2009) determined accelerated TFP growth scenarios in consultation with the Ministry of Agriculture (MoA). In this study, we implement a baseline scenario and four separate accelerated TFP growth scenarios running from 2009 to 2015:

BASE – The three agricultural subsectors follow their historical trend (1998 to 2007) of annual productivity growth for all years. These growth rates, in weighted averages, are: cereals (2.2 percent); cash crops (0.6 percent), and livestock (0.5 percent). In this simulation, the weighted average of annual TFP growth across all agricultural activities is 1.2 percent.[3]

CEREAL – Annual TFP growth in the cereal sub-sector averages 2.2 percent between 2005 and 2008, and rises to 4.3 percent during the simulation period (2009–2015). All other sub-sectors follow their baseline trend. The weighted average of annual TFP growth for all agricultural activities is 1.9 percent.

CASH CROP – Annual TFP growth in the cash crops sub-sector averages 0.6 percent between 2005 and 2008, and rises to 2.4 percent during the simulation period. All other sub-sectors follow their baseline trend. The weighted average of annual TFP growth for all agricultural activities is 1.7 percent.

LIVESTOCK – Annual TFP growth in the livestock sub-sector averages 0.5 percent between 2005 and 2008, and rises to 3.1 percent during the simulation period. All other sub-sectors follow their baseline trend. The weighted average of annual TFP growth for all agricultural activities is 2.0 percent.

CAADP – In the simulation period, the three sub-sectors experience simultaneous increases from the baseline trends of the same magnitude as those applied in the separate scenarios—cereals 4.3 percent, cash crops 2.4 percent, and livestock 3.1 percent.

The weighted average of TFP growth across all agricultural activities is similar across simulations. Yet, the *composition* of this growth differs significantly, driving the differences in outcomes which will be explored in the following paragraphs. Furthermore, while aggregate TFP shocks are similar when weighted to the *baseline* shares of the activities, in successive years the aggregate TFP shock under CEREAL will become progressively larger, as accelerated cereal activities gain higher shares in the economy.

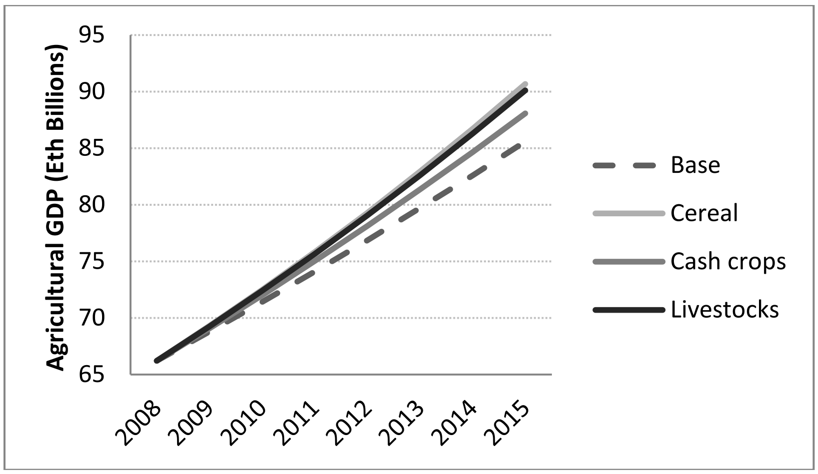
[3] Individual activities' shares of total agricultural value-added in 2005 are used as weights here.

4.2. Results

4.2.1. Effects on GDP growth rates and aggregate performances

In terms of efficiency in raising aggregate quantities, simulation results indicate a close equivalence between the various TFP-growth scenarios. This is somewhat in contrast to previous literature that emphasized cereal-led growth as the optimal strategy. Figure 4.1 shows this graphically by plotting the time series of simulated agricultural GDP over the period 2008 to 2015. The LIVESTOCK and CEREAL simulations appear as basically equally effective at delivering agricultural GDP growth.

Figure 4.1. Agricultural GDP effects



Source: Authors' calculations

Three mechanisms are at play. The re-allocation of productive resources is the first. The LIVESTOCK simulation, for example, markedly raises the productivity of livestock-related activities above its baseline trend, spurring production growth in excess of demand. As a result, the prices of livestock commodities fall. Furthermore, after the TFP acceleration, less factor inputs are needed to produce a given amount of livestock commodities. Some mobile factors such as labor, livestock, and land are hence re-allocated to activities where TFP growth is less pronounced.

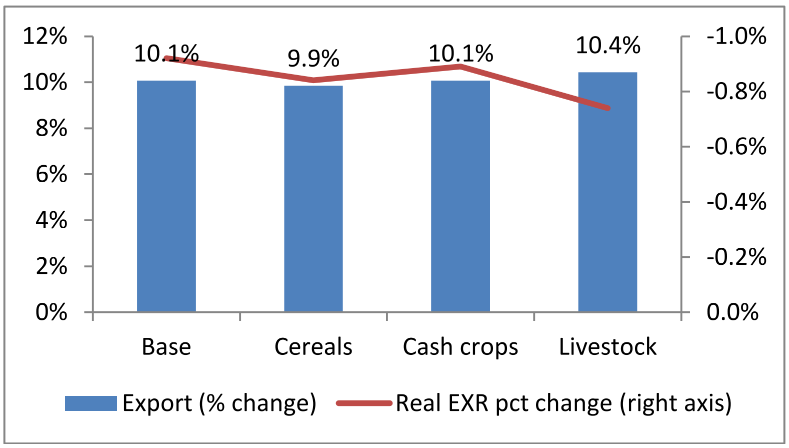
In our model, domestic output destined to domestic markets is imperfectly substitutable with output destined to export markets. An expansion in domestic supply is thus always shared among the domestic and export channels. As a result, when the domestic supply of a domestically consumed exportable rises faster than domestic demand, its equilibrium price in the model will fall. Incentives for expansion in production are thus curtailed and incentives for re-allocation of resources arise. In other words, the pace of domestic demand growth is often the binding constraint in equilibrium. This mechanism is at the heart of the results.

The draft power interlinkage plays here a crucial role, as it enables the model to capture the re-allocation process just described. Livestock TFP growth spurs overall economic growth by both promoting livestock GDP and by supporting the large and high-potential cereal sector. As draft power has often been subsumed under physical capital, previous analyses largely missed this process.

Growth in the livestock capital stock is the second mechanism. In the model, investment in livestock, fixed at the historical trend rate, generates stock growth of approximately four percent per year. As the model solves for successive years, the livestock factor becomes more abundant and cheaply available. Livestock-intensive activities benefit the most from this process and so does the LIVESTOCK simulation, which concentrates TFP growth on these activities. Cereal activities, on the other hand, are intensive in the use of land and labor—one is a fixed factor and the other an exogenously slow-growing one. Livestock-led growth thus enjoys a dynamic advantage related to its factor intensity. Again, livestock capital stock growth was not allowed in the original model, so that previous comparisons of crop and livestock led growth could not capture this point.

The third mechanism is current account balancing. Agricultural commodities constitute the major exports of the economy. Accelerated agricultural TFP expansion thus results in significant export growth. The current account balance between exports and imports has to be restored through an appreciation of the real exchange rate. As it will be explained later, growth in absorption is largest under the LIVESTOCK simulation. Consequently, demand for imports is also the largest in this simulation. Less of a real exchange rate appreciation is thus needed under the LIVESTOCK simulation to balance the current account. As a result, total export growth is the largest. Figure 4.2 shows this graphically.

Figure 4.2. Percentage change in export value and exchange rate 2005–2015



Source: Authors' calculations

The combined effect of these three mechanisms sustains economic growth in agriculture and the overall economy under the LIVESTOCK scenario. Even as the average TFP shock imposed in this simulation becomes progressively smaller as compared to that of the cereal-led growth scenario, its macro effects on agricultural and overall GDP are of a closely similar magnitude.

Table 4.1. 2009–2015 percentage change in value-added for sub-sector, agricultural sector, and overall economy

	Sub-sector	Agricultural sector	GDP
BASE		3.7%	6.4%
CEREAL	6.4%	4.6%	6.6%
MARKET	4.1%	4.2%	6.5%
LIVESTOCK	5.5%	4.5%	6.7%

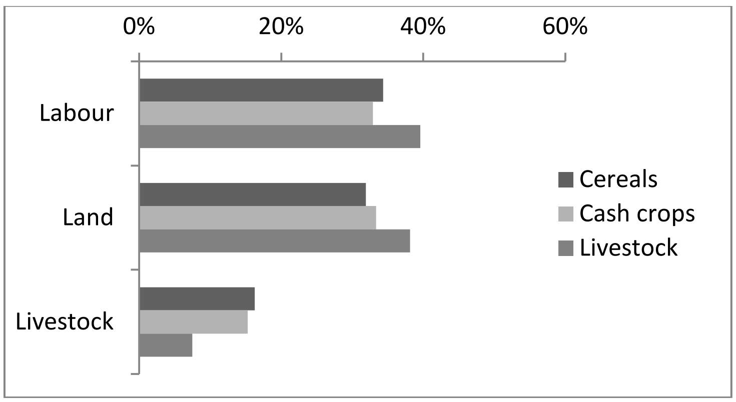
Source: Authors' calculations

4.2.2. Effects on welfare

There is also a welfare aspect to our results. The reallocation in factor demands explained above favours different factors in different simulations. In LIVESTOCK, livestock-factor intensive activities experience a faster shock in productivity. Demand for existing livestock factor increases the least and so does its price and returns. Demand for labor, and agricultural labor in particular, is instead quite strong. In CEREAL, on the other hand, the accelerated cereal activities are intensive in the use of land and labor. As the price for cereal activities falls and the factors are reallocated, returns to labor fail to increase much.

As Figure 4.3. shows, consistent with our analysis, returns to labor held by poor households rise the most in the LIVESTOCK simulation. In such a simulation, returns to livestock grow the least. But, as labor is the predominant asset of the poor, the former effects more than compensate for the latter. The net effect is such that poor households' incomes grow the most when agricultural growth is livestock-led.

Figure 4.3. Factor income effects for poor households



Source: Authors' calculations

The repercussions of this result in terms of food security are less strong, however. Consumption of staples is in fact determined by both poor households' income and by staple prices. The latter are lowest in the cereal-led growth scenario. CEREAL hence delivers the highest average annual growth rate in poor households' food consumption of about 4.4 percent. Average growth in poor households' food consumption is 3.6 percent in the baseline and 4 percent in the livestock scenario.

5. Conclusions

The livestock sector directly supports the livelihoods of a large proportion of rural as well as urban and peri-urban households in Ethiopia. The sector contributes a substantial share of total value-addition in the Ethiopian economy; it is strongly linked to other agricultural activities, through draft power in particular; it provides employment to a large number of people; and it is a major source of foreign exchange.

However, the important role of the livestock sector has often been overlooked by policymakers as well as researchers. Researchers neglect the livestock sector mainly for methodological reasons: biological and economic interactions and dynamics are a great deal more complex for livestock production systems than in crop production. This bias seems to have been compounded by the perception of policymakers that food security concerns can be addressed by focusing only on production of staple crops.

This study set out to overcome the shortcomings in existing economywide modeling. The study is intended to inform policymakers regarding the economywide direct and indirect outcomes of enhancing productivity growth for the livestock sector. The study extends an existing dynamic CGE model developed for examining policy priorities in the agricultural sector. It simulates a number of agricultural growth scenarios where productivity in different sub-sectors grows at an accelerated, yet realistic rate. Significant findings are obtained both in terms of aggregate value-added effects and in terms of welfare.

Simulation results indicate that, compared to accelerated cereal-led growth, improving productivity in the livestock sector has larger aggregate economic efficiency gains measured by value-added growth effects and by improvements in the external sector: a smaller real exchange rate appreciation and larger export earnings. As factors are re-allocated across sectors of the economy, further expanding TFP growth in the sector with the best baseline productivity performance runs into diminishing returns. A balanced agricultural growth model, where productivity gains are more evenly distributed across sub-sectors, is preferable. In Ethiopia, this means investing more in expanding the productivity of livestock. Furthermore, although livestock is not the predominant factor owned by poor households, its accelerated productivity growth brings about higher gains in labor incomes than in the accelerated cereal sector scenario, and only slightly smaller gains in poor households’ consumption of food. These general equilibrium results are of wide importance, as they point to the potential of a previously neglected lever for the eradication of poverty.

Appendix

Appendix Table A.1. Livestock numbers and price per head in ETB, in thousands

			AEZ-1		AEZ-2		AEZ-3		AEZ-4		AEZ-5	
			Qty	Price	Qty	Price	Qty	Price	Qty	Price	Qty	Price
Cattle	male	vy	16.4	0.8	583.9	2.1	104.9	1.2	420.4	1.4	584.6	1.4
	female		15.8	0.8	636.1	1.2	105.3	1.0	431.6	1.0	753.7	1.2
	male	yn	13.0	0.8	474.4	2.1	95.7	1.2	329.6	1.4	347.3	1.4
	female		16.2	0.8	495.5	1.2	102.4	1.0	363.4	1.0	488.0	1.2
	male	im	24.3	1.5	962.8	1.5	146.8	0.9	616.4	1.1	480.7	0.7
	female		35.3	1.2	1134.3	0.9	216.4	0.8	745.2	0.8	797.3	0.7
	male	ad	76.7	2.6	4413.1	2.8	384.9	2.1	2549.7	2.5	986.5	2.2
	female		132.0	1.6	4708.7	1.7	898.7	1.1	2995.9	1.6	3646.5	1.5
	male	fn	2.5	2.6	300.0	2.8	7.5	2.1	155.1	2.5	38.8	2.2
	female		5.2	1.6	233.6	1.7	37.2	1.1	125.3	1.6	78.1	1.5
Goats	male	vy	40.7	0.2	259.4	0.2	151.4	0.2	682.9	0.2	1612.8	0.2
	female		42.0	0.2	288.7	0.2	153.7	0.2	752.8	0.2	1681.6	0.2
	male	yn	18.4	0.2	95.2	0.2	64.4	0.2	285.0	0.2	529.7	0.2
	female		21.1	0.2	131.1	0.2	79.2	0.2	418.9	0.2	688.6	0.2
	male	ad	16.1	0.2	89.1	0.2	57.9	0.2	209.0	0.1	444.0	0.1
	female		21.9	0.2	172.1	0.2	94.9	0.2	475.2	0.2	908.3	0.1
	male	fn	29.0	0.3	136.8	0.3	84.1	0.4	351.1	0.5	567.6	0.3
	female		139.3	0.2	817.4	0.2	466.1	0.2	2248.3	0.3	4395.3	0.2
Sheep	male	vy	19.4	0.2	1210.1	0.2	104.1	0.2	571.9	0.2	805.5	0.2
	female		25.1	0.2	1237.5	0.3	124.2	0.2	619.1	0.2	849.6	0.2
	male	yn	12.4	0.2	285.0	0.2	31.5	0.2	184.8	0.2	333.9	0.2
	female		18.0	0.2	432.7	0.3	49.1	0.2	244.3	0.2	499.0	0.2
	male	ad	9.5	0.3	219.0	0.3	25.8	0.2	166.6	0.2	314.8	0.1
	female		23.8	0.2	572.9	0.2	68.1	0.2	317.2	0.2	635.3	0.1
	male	fn	21.0	0.4	303.7	0.3	33.4	0.3	270.5	0.4	658.9	0.3
	female		94.9	0.2	3818.1	0.2	397.9	0.3	1943.6	0.2	3235.6	0.2
chicken	male	fn	40.3	0.0	1154.4	0.0	147.2	0.0	875.0	0.0	236.7	0.0
	female		113.6	0.0	3877.0	0.0	576.3	0.0	3005.0	0.0	819.5	0.0
	male	ad	24.1	0.0	436.9	0.0	79.1	0.0	406.3	0.0	89.6	0.0
	female		46.0	0.0	938.2	0.0	153.0	0.0	794.1	0.0	151.5	0.0
	male	vy	60.4	0.0	1332.6	0.0	239.5	0.0	996.9	0.0	166.8	0.0
	female		114.7	0.0	2853.6	0.0	461.5	0.0	1872.7	0.0	279.6	0.0
Camel	male	yn	0.0	-	23.9	1.8	0.0	-	11.9	1.6	117.1	1.9
	female		0.0	-	16.7	2.1	0.0	-	14.1	2.2	245.2	2.0
	male	ad	0.0	-	38.4	1.3	0.0	-	40.4	1.3	196.7	1.3
	female		0.0	-	65.3	1.5	0.0	-	38.0	1.5	687.3	1.5

Source: Computed and organized by authors (original data obtained from Central Statistical Authority)
Note: vy = very young; yn = young; im = immature; ad = adult; fn = final stage of their lifespan

References

Ahmed, H., A. Amogne, T. Tebekew, B. Teferra, E. Tsehaye, P. Dorosh, S. Robinson, and D. Willenbockel. 2009. *A Regionalized Social Accounting Matrix for Ethiopia, 2005/06: Data Sources and Compilation Process.* Addis Ababa, Ethiopia: Ethiopian Development Research Institute (EDRI). (processed).

Behnke, R .2010. The *Contribution of Livestock to the Economies of IGAD Member States Study Findings, Application of the Methodology in Ethiopia and Recommendations for Further Work.* Working Paper 02 – 10 IGAD LPI.

Diao, X., E. Yeldan, and T. Roe. 1998. "A Simple Dynamic Applied General Equilibrium Model of a Small Open Economy: Transitional Dynamics and Trade Policy." *Journal of Economic Development* 23 (1): 77–101.

Dorosh, P., and P. Thurlow. 2009. *Implications of Accelerated Agricultural Growth on Household Incomes and Poverty in Ethiopia: A General Equilibrium Analysis*. ESSP II Discussion Paper 02. Addis Ababa: International Food Policy Research Institute / Ethiopia Strategy Support Program II.

Kapuscinski, C. A., and P. G. Warr. 1999. "Estimation of Armington elasticities: an application to the Philippines." *Economic Modeling* 16 (2): 257–278.

Lofgren, H., R. L. Harris, and S. Robinson. 2002. *A Standard Computable General Equilibrium (CGE) Model in GAMS*. Trade and Macroeconomics Division Discussion Paper 75. Washington, D.C: International Food Policy Research Institute.

Ministry of Agriculture. 2010. Ethiopia's Agricultural Sector Policy and Investment Framework: 2010–2020, Final Report.

NEPAD-CAADP. 2010. *CAADP Review: Renewing the commitment to African agriculture, Final Report.* NEPAD Planning and Coordinating Agency

Tafere, K., A. S. Taffesse, and S. Tamiru. 2010. *Food Demand Elasticities in Ethiopia: Estimates using Household Income and Consumption Expenditure (HICE) Survey Data*. ESSP II Discussion Paper 11. Addis Ababa: International Food Policy Research Institute / Ethiopia Strategy Support Program II.

Tafere, K., and I. Worku. 2011. "Consumption Patterns of Livestock Products in Ethiopia: Elasticity Estimates using HICE (2004/05) Survey Data." Paper presented at the 9th conference of the Ethiopian Economic Association, Addis Ababa, Ethiopia, July 21-23.