Methods and data needs to estimate the economic (market) value of livestock at different spatial scales

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Summary

Assessing the economic value of livestock, e.g. cattle, goats, sheep, pigs, chickens, and fish can offer information about their financial performance and economic importance at farm, national and global scale. Such information is needed for decision making about livestock finance, investment, and strategic development. The aim of this study was to provide an overview about the key livestock valuation methods and associated data requirements. The study was conducted using a literature review. Five key livestock valuation methods were identified and described which include *a)* historical costs, *b)* net current market value, *c)* replacement costs, *d)* net present value, and *e)* cost of production. The findings of this study may be of interest for livestock scientists, veterinarians, policy makers and other stakeholders who aim to assess the economic value of livestock herds. The outcomes of this study were important for the Global Burden of Animal Diseases (GBADs) programme to identify methods for the estimation of the economic value of livestock at the global scale and for the Ethiopia and Indonesia case studies.

Keywords

Approach – Data – Economic value – Livestock – Market – Method – Price – Scale – Valuation.

Introduction

Livestock stocktake is vital for decision makers to understand the performance and importance of farm animals for livelihoods, food security and farm business analysis. While livestock stocktakes are often conducted through assessments of populations or biomass, the economic value of livestock provides an alternative metric to account for the performance and importance of farm animals. For example, information about the

economic value is required by industry stakeholders at different scales, e.g. farm, national, global, as basis for finance and investment decisions and for strategic development, e.g. herd rebuilding, disease treatment and prevention (e.g. Rehman *et al.* [1] and Huntington *et al.* [2]).

This study focusses on the economic market value of livestock. This value is derived from markets, i.e. physical, or virtual places, at which livestock, and production inputs are traded through demand and supply which determine their market price. The market price typically refers to the physical traits of livestock, e.g. species, breed, sex, age, weight, and the condition of an animal at a specific point in time (current value) (e.g. Wolfová and Wolf [3]). Other factors such as market location, seasonal and environment conditions that affect feed availability, e.g. rain, drought, market distortions such as taxes, subsidies, and supply-demand market dynamics can affect the market price of livestock (e.g. Ayele *et al.* [4]). To determine the value of livestock herds, current price data and number of animals (i.e. heads) with similar traits are required. Yet, such data is not always available or accessible and therefore different livestock valuation approaches may need to be considered by analysts.

The aim of this study was to provide an overview of key livestock valuation methods and associated data requirements at farm, national and global scales.

A literature and datasets review were conducted to identify and summarise main market-based valuation methods for livestock. For this study, livestock includes cattle, sheep, goats, buffalo, deer, horses, pigs, poultry, and fish which are farmed for commercial purposes, e.g. acquisition for resale, breeding, and productive use. The scope of this study excludes valuation methods for *a)* services that livestock perform, e.g. insurance, traction [5], *b)* outputs generated from farm animals, e.g. meat, milk, eggs, skin/hides, and offal [6], and *c)* non-market goods and services of livestock, e.g. cultural/religion and companion services, continuation of traditional breeds [7].

While the findings of this study may not be entirely novel for economists or farm management experts, it may be of interest for livestock scientists, veterinarians, policy makers and other stakeholders who aim to assess the economic market value of livestock herds. The outcomes of this study were also important for the Global Burden of Animal Diseases (GBADs) programme to identify methods for the estimation of the economic value of livestock at the global [6] and national scale for the Ethiopia [8,9] and Indonesia [10] case studies.

Materials and methods

A literature review was undertaken to identify methods that are used to estimate the economic market value of livestock. The review was conducted using the literature databases Google Scholar and Scopus. Relevant grey literature, e.g. reports, theses, were also assessed. The initial search of titles, abstracts and keywords comprised the following combinations of terms: 'value/valuation + livestock'. The initial search was followed by a series of iterative searches in which the following terms were added to the original search items: 'method'; 'econ', 'data' and 'price'. Relevant articles were assessed, first through review of the abstract, then by full read. Once the key valuation methods were identified through the screening process, a search for publications that cite the specific methods was undertaken. This search included the terms: '[method name] + livestock' and added combinations of 'value/valuation', 'data', and 'price'. A total of 29 relevant publications were identified and fully assessed.

Examples for data sources that have been or could be used to apply the valuation methods at the different spatial scales were identified using Google data search and references in cited publications. Information about the availability/accessibility of data at different scales was also derived based on findings from various GBADs projects [6,8-11].

Results

In the accounting context, livestock is considered as an asset, i.e. part of farm inventories [12,13]. An asset is a resource that is controlled by an entity, e.g. business, as a result of past events from which future economic benefits are expected to flow to the entity [13,14]. This definition recognises the inherent capacity of livestock for growth, production, procreation, and degeneration which contain potential economic benefits and services which are subject to continual variations during their lifetime (e.g. Petzke [13] and the Australian Accounting Standards [15]. Livestock are considered as current assets if held for use and sale within a year such as trading stock; and as non-current assets if held for more than one year with productive use that is subject to depreciation (i.e. loss on value over time) [12,13].

Five key methods for livestock/asset valuation were identified, these are *a)* historical costs, *b)* net current market value, *c)* replacement value, *d)* net present value, and *e)* costs of production (e.g. Petzke [13], the Australian Accounting Standards [15], Bir *et al.* [16] and Hagerman *et al.* [17] (see Table I). Sophisticated econometric techniques exist

to estimate values for some of the identified approaches when data are scares, e.g. vector error correction models to estimate the net current market value, hedonic pricing models to derive replacement costs (e.g. Ayele *et al.* [4] and Hagerman *et al.* [17]. These techniques are here not outlined further for simplicity.

Economic livestock accounting is typically conduced on an annual basis, e.g. calendar year or financial year, which is a feature that can be applied to all livestock valuation methods.

The five key methods and their data needs at farm, national, global scales are briefly described in the following sub-sections. The methods focus on deriving the current value of livestock or close proxies for it, i.e. the asset value at a specific point in time. For more detail on individual livestock valuation methods, the reader should refer to the provided references.

Historical costs

The amount of cash or cash equivalent paid for an asset at the time of acquisition (acquisition costs), excluding accumulated depreciation and production input costs allocated over the estimated the life or specific period of an animal's productive life [12,13]. Historical costs are also referred to as 'past entry value' or 'market buying value' of livestock [12,13]. This method may be considered by analysts for stocktake valuations as a proxy when data for net current asset values (NCMV, see below) are unavailable. Historic costs can also be used to assess changes in acquisition costs over time or spatial scale. Advantage of the historical costs method is that acquisition cost values are relatively objective, i.e. limited to risk for bias, and easy to understand [13]. A disadvantage of historical costs is that livestock acquisition costs are non-current (past/historic values) which may not appropriately reflect an assets current value. For example, acquisition costs are not a constant measurement unit through time and may change due to changes in production input prices as well as depreciation of the livestock assets [13]. Hence, the current value of a farm animal is considered at its (past) acquisition value.

The historical costs method requires data about assets' acquisition costs which consider the species-specific physical traits, e.g. age, breed, body condition. For herd level assessments, data about the herd population, e.g. number of heads or biomass/lightweight equivalents is also needed. Such data are commonly available at farm level from financial records, e.g. enterprise budgets, of previous production years

which can be obtained by analysts through farm surveys. At national scale, proxy records for historical average annual market buying prices are often available/accessible from historic local/national market reports, i.e. selling prices as proxy, industry peak bodies or government authorities, e.g. annual livestock census. See examples in the Supplementary material. At global scale, a proxy data set of historic farm gate prices for various livestock types from FAO [18] can be considered for analysis. The historical cost method typically provides a baseline for other livestock valuation methods, e.g. net present value, cost of production [19,20].

Net current market value (NCMV)

The estimated current market selling value of an asset, less all costs incurred in marketing, selling and distribution of the asset to customers [13]. That is the amount that could be raised by the sale of the asset during the normal course of business. This is also referred to as the 'market selling value' which differentiates NCMV from the historical costs method (i.e. uses 'market buying value'). The NCMV method assumes that the value of livestock, conditional on physical traits, is reflected in the net price at which it is sold at a market at a specific point-in-time, e.g. external aspects [13]. This method provides the most realistic and useful method, e.g. avoidance arbitrary depreciation, for the estimation of the economic value of farm animals [13]. The NCMV is typically used in stocktakes to determine the economic value of assets and can also be used to analyse changes in the NCMV of assets over time or spatial scale. A disadvantage of the NCMV method is that local markets may not always sell assets with specific specifications, e.g. age, breed, body condition [21]. In such circumstances, leeway may be given for using *a)* data that offers livestock specification with similar physical traits, e.g. different age group, breed or body condition, *b)* data that is available for different assessment scales, e.g. use national average data if farm scale data is unavailable or *vice versa*, or *c)* alternative valuation methods, e.g. historical costs, cost of production (COP, see below).

The NCMV method requires information about market selling prices of assets or farm gate prices which consider the physical traits of the assets. For herd level valuations, number of heads/population or biomass/lightweight equivalents are needed. As for other livestock valuation methods, data for NCMV is commonly available at farm level. At national scale, data for the average market value or average (farm gate) price per animal are typically available and accessible from national livestock census', market reports, or industry associations (see Supplementary material). Yet, these values/prices are often aggregated at livestock type level, meaning that physical traits across a herd are not reflected in the data. This limits the analysis of value dynamics within livestock herds and

at sub-national scale and across different physical traits, e.g. age groups, breeds. Studies which used national scale market value data for different livestock types include Li *et al.* [8], Jemberu *et al.* [9] and Smith *et al.* [10]. At the global scale, FAO [18] offers livestock farm gate price data for all countries which can be matched with biomass data to derive proxies for the global economic value of farm animals as conducted by Schrobback *et al.* [6] under the GBADs programme. Since FAO [18] gathers livestock price and biomass data from national records at species level (see above), the available global NCMV data currently lacks disaggregation into physical traits of livestock. It should also be noted that NCMV and historical costs data are available for a collection of countries, e.g. Eurostat [22], which may be used for assessments at national and regional scales.

Replacement costs

The amount of cash or cash equivalent that would currently be needed to replace an asset with an asset of equal capacity (e.g. physical traits, performing same tasks, similar condition) [13]. Replacement costs method is typically used for asset replacement assessments, e.g. herd restructure [13] or for the assessment of livestock loss due to diseases or natural disasters [17,23]. Replacement costs are typically considered as the 'entry value' of a replacement asset, which is equivalent to its NCMV (see above). The advantage of using the NCMV over historic costs in determining the replacement costs is that changes in the value of the asset that is being replaced, e.g. invested production costs, productivity, depreciation are considered by the NCMV, while the use of historic costs would neglect changes between the asset's historic entry and current exit value [13]. A disadvantage of the replacement cost method is that market prices for assets that require replacement may not always be available, e.g. same capacity/physical traits, if the market doesn't sell these assets [13].

Data required for the replacement cost method include current net livestock selling prices of assets with similar physical traits/capacity (age, breed, condition, etc.) or farm gate prices [23]. As for all other valuation methods, data about the population size or biomass/liveweight equivalent is needed for herd level valuations. While replacement costs data are typically available at the farm level, such information is more difficult to access at a national level (e.g. Hagerman *et al.* [17]). Proxies such as national livestock sales data (for non-identical asset traits) and nationally representative costs of production data may be used to approximate the replacement value of livestock [17,24]. A study at global scale using the replacement costs method for livestock valuation could not be identified.

Net present value (NPV)

The discounted present value of the future net cash inflows/benefits (benefits less costs), that the asset is expected to generate either from its use and subsequent sale [13,25]. The NPV is typically used to estimate the potential future earning capacity of assets as a baseline for investment decisions, e.g. investments in assets, herd restructure. The NPV method uses discounting which is the process of converting a value received in a future time period to an equivalent value received in the current period [25]. Details on how to derive the NPV is provided in Campbell and Brown [25]. An advantage of the NPV method is that it takes an *ex-ante* (before the event) or forecasting perspective on asset values which can be useful for investment decisions. A disadvantage of the NPV approach is that the selection of an appropriate discount rate can be arbitrary. Moreover, the attribution of future cash flows to assets includes high level of risks/uncertainties, and the timing of future cash flow is difficult to predict.

Data needed for NPV estimation, includes expected acquisition costs, e.g. current net livestock selling price or farm gate prices as well as expected future benefits from maintaining an asset over a specific period (e.g. lifetime, 3 years), e.g. income, selling value, and production costs. Furthermore, an 'appropriate' interest (discount) rate is needed, its selection can be arbitrary and therefore affected by bias. Population/head number or biomass/liveweight equivalents are needed for herd level assessments.

Studies that used the NPV for livestock valuation at sub-national scale include Meek *et al.* [26], Scott *et al.* [27] and Dobes *et al.* [28]. At national scale, required data may be available from industry or government associations. An example for a study that used the NPV method at a national scale is provided by Stalder *et al.* [29]. At global scale no study and data to estimate the NPV could be identified.

Cost of production (COP)

The sum of an asset's acquisition costs (i.e. historic costs) and the total costs spent to maintain an asset over a specific time period (e.g. 3 years after purchase) (e.g. Kica and Szczypa [20]). This valuation method is used in conjunction with stocktakes if the NVMV is unavailable. COP is also used in other contexts such a production cost analyses as recently undertaken by Schrobback *et al.* [11] as part of the GBADs programme. The advantages of the COP approach that it offers detailed information about inputs and costs of maintaining assets. A disadvantage of this method is the use of enterprise-based production data (a single value point) which may not be representative, e.g. can reflect

economies of scale for large farms or costs linked to production in a specific agroecological zone/production system.

The COP method requires asset's acquisition costs and data on the assets' production input costs over time such as feed, supplements, labour, breeding, health, and land expenses [17,30,31]. Details on different production cost types that should be considered for this livestock valuation method are provided by Schrobback *et al.* [11]. As for all other valuation approaches, data about population size or biomass/liveweight equivalent are needed for herd level assessments.

Data for COP estimations are typically available at farm level (farm enterprise budgets). At national level, livestock industry peak bodies, government institutions or private organisations may compile national average livestock COP data for farm benchmarking purposes [30] (see Supplementary material). Hagerman *et al.* [17] used COP as a livestock valuation method at national scale. At the global scale, there is currently only data available for selected livestock species and a limited range of countries and most of these sources are not publicly accessible (see Supplementary material). This limits the use of the COP method for a livestock valuation at global scale.

Which livestock valuation method to choose?

The summary of the five key livestock valuation methods (see Table I) shows that they have slightly different data requirements and follow different principles; hence, they can lead to different results. Furthermore, each method has advantages and disadvantages. The choice of livestock valuation method should depend on the *a)* purpose of assessment, e.g. disclosure of financial performance information for reporting requirements, decision making for allocation of scarce resources such as finance and investment, *b)* spatial scale of analysis, e.g. farm, national, global level, and *c)* data availability/accessibility (e.g. Wolnizer [12] and Petzke [13]). Therefore, analysts should consider and compare all five methods for the specific context of their analysis.

Conclusions

The study offers an overview of key methods that are used to estimate the economic value of livestock. Recommendations for the selection of a methods to conduct a livestock value assessment were provided, e.g. consideration of analysis purpose, spatial scale and data availability/accessibility.

The findings show that data availability/accessibility for economic valuations of livestock is often limited at national and global scale, this includes price and population/biomass data. Advanced econometric valuation techniques, e.g. hedonic pricing models or vector error correction models, have been used estimate the economic market values for some of the identified livestock valuation methods in circumstances where data is sparse (e.g. Ayele *et al.* [4] and Hagerman *et al.* [17]). Yet, improved efforts should be put into systematic livestock price and population/biomass, e.g. heads, liveweight equivalent, data collection that reflect physical traits of animals. Aggregated information at livestock species level is insufficient for reliable economic value and biomass estimation. Improved access to privately collected and owned datasets is also required for research purposes, particularly in the contexts of public good research such as identifying the global and national economic value of livestock that is at risk to animal diseases [6,11].

Livestock valuation methods presented in this study are based on market prices/costs such as prices of production inputs, buying/selling prices and replacement/production costs. These market values do not account for the 'total economic value' of farm animals such as the output that is generated form animals e.g. milk, meat, eggs, offal, skin/hides, and non-market values, e.g. religious/cultural and companion value of livestock. These additional economic values that livestock provide society are important to consider for decision making at farm, national and global scales.

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Table I

Key livestock valuation methods and general data availability at various scales (species/herd level)

Notes: ✓for data available, [✓] for proxy data available, {✓} for data available for some species in some countries, x for data typically unavailable. Data availability may not include accessibility of data. Data availability refers to livestock species (aggerated) level. 'assess' for assessment'

Valuation method	Description	Purpose	Advantages	Disadvantages	Data needs	Data availability by assess. scale		
						Farm	National	Global
Historical cost	Cash equivalent paid for assets at the time of acquisition	Stocktake/asset valuation - as proxy when current market selling values (prices) are unavailable; analysing changes in asset's acquisition costs over time/spatial scale	Objective method (limited risk for bias), easy to understand	Use of (past) acquisition costs, acquisition costs are not constant over time, e.g. changes in input prices and depreciation over time are ignored	Asset acquisition costs (consider age, breed, condition, etc.); population/head number or biomass/liveweight equivalents	✓	[✓]	[✓]
Net current market value (NCMV)	Current market selling value (price) of an asset, less marking, selling and distribution costs	Stocktake/asset valuation – when current market values (prices) are available; analysing changes in asset's NCMV over time/spatial scale	Reflects an 'up-to-date' (current) asset value, avoids arbitrary depreciation	Market prices for comparable assets (breed, age, condition) in current heard may not be available if markets don't sell these assets	Current net livestock selling price or farm gate prices (consider age, breed, condition, etc.); population/head number or biomass/liveweight equivalents	✓	✓	✓
Replacement cost	Current cash equivalent that would be needed to replace assets with assets of equal capacity	Asset replacement assessments (herd restructure), stock loss assessments (disease, natural disasters)	Use of NVMV as replacement value (see above)	Market prices for assets that require replacement may not always be available (same capacity, age, breed condition) if the market doesn't sell these assets	Current net livestock selling prices of assets with similar (or dissimilar – as proxy only) physical traits/capacity (age, breed, condition, etc.) or farm gate prices; COP data (as proxy only); population/ head number or biomass/ liveweight equivalents	✓	[✓]	x
Net present value (NPV)	Discounted present value of the future net cash inflows/benefits (benefits less costs) that assets are expected to generate from their use and/or sale	Assessment of assets potential future earning capacity (investments, herd restructure)	*Ex ante* valuation approach, reflects the present value of the future cash flow that an asset is expected to generate	Selection of a discount rate can be arbitrary, attribution of future cash flows to assets includes high level of risks/uncertainties, timing of future cash flow is difficult to predict	Current net livestock selling price or farm gate prices (consider age, breed, condition, etc.; expected income, selling value, production costs; appropriate discount rate; population/head number or biomass/liveweight equivalents	✓	{✓}	x
Cost of production (COP)	Sum of assets' acquisition costs and total costs spent to maintain the assets up to a specific point of time	Stocktake/asset valuation - as proxy when current market selling values (prices) are unavailable; analysing changes in asset's COP over time/spatial scale	Offers detailed information about production inputs and costs associated with maintaining an asset	Use of enterprise-based production data (single value point) may not be representative e.g. reflect economies of scale for large farms, costs for specific agroecological zone/ production system	Asset acquisition costs, all production costs up to a specific point of an asset's lifetime, e.g. feed, supplements, labour, breeding, health, and land expenses (farm enterprise budgets); population/ head number or biomass/liveweight equivalents	✓	{✓}	{✓}

Source: adapted from Petzke [13] and Hagerman *et al.* [21]

Supplementary material

Farm scale data

Farm scale data for the use of all livestock valuation methods may collected by analysts through farm surveys.

National and global scale data

The following data sources were compiled in August 2023.

Historical costs examples

- Historical livestock prices – United States of America: https://www.ers.usda.gov/data-products/livestock-and-meat-domestic-data/livestock-and-meat-domestic-data/#Livestock%20Prices
- Historical cattle and sheep prices – Australia: https://www.mla.com.au/prices-markets
- Historical cattle prices – Manitoba, Canada: https://gov.mb.ca/agriculture/markets-and-statistics/statistics-tables/pubs/histlivestock-prices-per-cwt.pdf
- Historical farm gate prices for various livestock species – Global https://www.fao.org/faostat/en/#data

Net current market value (prices and heads) examples

- Market livestock prices – United States of America: https://www.ers.usda.gov/data-products/livestock-and-meat-domestic-data/livestock-and-meat-domestic-data/#Livestock%20Prices
- Market cattle and sheep prices and heads sold – Australia https://www.mla.com.au/prices-markets
- National averages of prices and heads for sheep, cattle, and pigs – United Kingdom
  Price: https://www.gov.uk/government/statistical-data-sets/livestock-prices-finished-and-store
  Population: https://www.gov.uk/government/statistics/livestock-populations-in-england
- Farm gate prices and populations for various livestock species – Global https://www.fao.org/faostat/en/#data

Cost of production examples

- Annual dairy production costs data (and other production data) collected through farm surveys in 52 countries by the International Farm Comparison Network (IFCN), https://ifcndairy.org
- Annual beef, sheep, and pig production costs data (and other production data) collected through farm surveys in 29 countries by Agri Benchmark, http://www.agribenchmark.org/home.html