Routledge
Taylor & Francis Group

Agrekon

Agricultural Economics Research, Policy and Practice in Southern Africa

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ragr20

The financial burden of African Horse Sickness: a case of the European Union trade ban on South Africa's horse industry

Zimbini Mdlulwa, Mampe Masemola, Baratang A. Lubisi & Petronella Chaminuka

To cite this article: Zimbini Mdlulwa, Mampe Masemola, Baratang A. Lubisi & Petronella Chaminuka (2021) The financial burden of African Horse Sickness: a case of the European Union trade ban on South Africa's horse industry, Agrekon, 60:4, 353-369, DOI: 10.1080/03031853.2021.1975549

To link to this article: https://doi.org/10.1080/03031853.2021.1975549

Published online: 29 Sep 2021.

AGREKON
2021, VOL. 60, NO. 4, 353–369
https://doi.org/10.1080/03031853.2021.1975549

The financial burden of African Horse Sickness: a case of the European Union trade ban on South Africa's horse industry

Zimbini Mdlulwa[a], Mampe Masemola[a], Baratang A. Lubisi[b] and Petronella Chaminuka[a]

[a]Economic Analysis Unit, Agricultural Research Council, Pretoria, South Africa; [b]ARC-OVR-Diagnostic Services Programme, Agricultural Research Council, Pretoria, South Africa

ABSTRACT
Globalisation and the increased movement of goods such as live animals and animal products across national borders can exacerbate the introduction and spread of diseases. This risk can be mitigated through adherence to trade control measures such as the Sanitary and Phytosanitary Measures (SPS) of the World Trade Organization (WTO). However, compliance with SPS measures usually results in additional production and trade costs. This paper applied cost–benefit analysis, using stochastic scenario analysis, to estimate the financial burden of SPS measures on exporting horses from South Africa to the European Union (EU). These measures were instituted following a ban on the direct export of horses from South Africa to the EU, triggered by outbreaks of African Horse Sickness (AHS) in the AHS Controlled Area in the Western Cape Province. Analysis revealed that compliance to existing SPS measures by exporting a horse via a third country is 1.67 times more costly than exporting directly to the EU. A strengthened public-private sector partnership is recommended to jointly identify the most efficient and effective ways to develop capacity for collaborative judicious investment in order to build a resilient horse industry thereby enabling employment creation and economic growth.

ARTICLE HISTORY
Received 30 April 2020
Accepted 26 August 2021

KEYWORDS
African Horse Sickness; EU; Mauritius; South Africa; SPS measures

1. Introduction

Trade liberalisation has allowed the movement of goods and services across national borders such as live animals and animal products. Animal movements within countries and across borders can exacerbate the introduction and spread of diseases (Dean et al. 2013). The importance of animal movements is well understood and international regulations such as those from the World Organisation for Animal Health (OIE) exist to mitigate the risks involved (Fevre et al. 2006). The risks can be mitigated through adherence to trade control measures such as the Sanitary and Phytosanitary Measures (SPS) of the World Trade Organization (WTO). The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) recognises the OIE as the international standard setting organisation for animal health and zoonotic diseases. The SPS Agreement specifically encourages the Members of the WTO to base their sanitary measures on international standards, guidelines, and recommendations, where they exist. The international standards are designed to facilitate safe international trade. However, when applying sanitary measures for international trade, the WTO recognises that each member has the independent right to set its appropriate level of protection. The WTO further stipulates that member countries should respect the provisions in the SPS Agreement when setting the specific measures. Subsequently, countries with a high level

CONTACT Zimbini Mdlulwa mdlulwaz@arc.agric.za Economic Analysis Unit, Agricultural Research Council, 1134 Park Street, Hatfield, Pretoria 0083, South Africa

of animal health, resulting from heavily funded animal health campaigns, have established requirements for the importation of animals or animal products at higher levels than the international standards developed by the OIE, justified through quantitative risk assessments based on available sound science (Torres 2013). Overall, the OIE standards provide for trade in animals and animal products to take place with an optimal level of animal health security, provided they are properly applied. Therefore, the application of the OIE standards is the best mechanism for avoiding disagreements, disputes, and other problems in international trade. The appropriate standards are contained in the OIE Terrestrial Code and Aquatic Code and related OIE Manuals for terrestrial and aquatic animals (see https://www.oie.int/en/standard-setting/terrestrial-code/).

The WTO SPS Agreement provides a framework of rules as to how governments can apply food safety, animal, and plant health measures, which directly or indirectly affect international trade. SPS measures are defined as non-tariff measures (NTMs) that are applied to protect animal or plant life or health within the territory of the member state from risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms (WTO 1995). Mostly, concentrated on agri-food products, SPS measures are estimated to cover 10% of world trade and 25% of product lines (Melo and Nicita, 2018). Usually, SPS measures are implemented through a diverse set of conditions such as import licences, inspection requirements, testing and certification requirements, and quarantine treatments, including relevant requirements associated with the transport of animals.

A literature review on the impact of NTMs on trade revealed a number of studies focused on the partial (country, regional, product or sector specific) impact of NTMs on agri-food trade (Xiong and Beghin 2011; Nimenya, Ndimira, and de Frahan 2012; Shepherd and Wilson 2013; Kang and Ramizo 2017; Santeramo and Lamonaca 2019; Schuenemann and Kerr 2019), but none on the movement of animals. This paper therefore, contributes to the literature analysing the impact of SPS measures on the movement of live animals in the field of agricultural economics, specifically international trade where such studies are limited. This study focuses on the financial cost incurred by exporters (horse owners) due to SPS measures imposed on a horse destined to participate in an international race competition in the EU. The EU imposed these measures to prevent the introduction of African Horse Sickness (AHS), an OIE listed disease of economic importance. It is anticipated that the findings of this study will provide critical information required by policy makers and industry stakeholders to guide policy and investment in livestock disease control in general, and AHS in particular.

Equids, especially horses, travel extensively to international countries on a permanent and temporary basis. They are traded for sale, breeding, or to compete at international equestrian events and races. However, horses are susceptible to diseases, in particular, African Horse Sickness (AHS), hence trading countries have to adhere to the SPS measures. AHS is a non-contagious, vector-borne, viral disease, transmitted from one animal to another through biting by infected *culicoides midges*. Susceptible herds can suffer up to 95% fatality rate (Sergeant et al. 2016). AHS is characterised by damage to the respiratory and circulatory systems of horses, accompanied by fever and loss of appetite. The disease is endemic in sub-Saharan Africa, with all nine serotypes occurring in many countries, including South Africa (Sergeant et al. 2016). There is no known treatment, although outbreaks of AHS can be prevented and controlled with registered vaccines and restricted animal movement. South Africa is one of the countries that moves horses globally to compete in horse racing events. However, participation of South Africa's horses in international events is hampered by the current ban instituted by European Union (EU) on direct export of horses from South Africa to the EU and other countries that have been free from AHS since 2011. AHS is an important disease affecting international trade; it is listed by OIE for the official recognition of disease status due to its severity and the potential risk it poses for rapid global spread. It is therefore, compulsory for member states like South Africa, to update the OIE concerning any change of disease status. The OIE Terrestrial Animal Code has a specific chapter that provides guidelines on conditions under which member countries should import equids dependent on the AHS status of the exporting country. This chapter was first adopted in 1968 with the last revisions adopted in 2014 (http://www.oie.int/fileadmin/Home/eng/Health_standards/tahc/current/chapitre_ahs.pdf).

The 1968 OIE AHS Chapter provides a basis upon which importing countries can refuse the import of horses from an AHS-infected country. Nevertheless, a majority of countries are not prepared to accept imports from AHS-infected areas of South Africa using this protocol (Sergeant et al. 2016). Prior to the existence of this chapter, South Africa exported very large numbers of horses to most parts of the world. The introduction of this chapter resulted in the vast majority of AHS free countries refusing to consider the importation of horses from AHS-infected countries. This became known as "The AHS Ban" and it is a non-tariff-based barrier to trade. Since 1968, the importation of South African horses has essentially been limited to other AHS-infected countries. However, the United States of America (see https://www.govinfo.gov/content/pkg/CFR-2020-title9-vol1/xml/CFR-2020-title9-vol1-part93.xml#seqnum93.308) and Mauritius are two AHS free countries that have allowed the importation of horses from AHS-infected countries. In the early 1990s, following the occurrence of AHS in Spain and Portugal, the European Union incorporated the then current OIE AHS Code Chapter into their legislative framework, which thereby allowed the importation of horses from AHS Free Zones of AHS-Infected Countries. In 1997, following bilateral negotiations, the EU adopted a Commission Decision that again allowed the importation of horses directly from SA into the EU for the first time since 1968 (see https://op.europa.eu/en/publication-detail/-/publication/9598ae77-95de-4dc8-a55e-331a4a278738). Whilst there have been amendments to this legislation since it was first adopted, it remains in force.

1.1 A historical perspective on incidences of AHS in South Africa

AHS is endemic to all provinces in the country except for the legislated AHS Controlled Area in the Western Cape Province, which was established in 1997 (Sergeant et al. 2016). AHS is seasonal and the majority of outbreaks occur from late spring through to autumn when vector midges are plentiful. Favourable climatic conditions, such as periods of drought followed by heavy rains, are particularly conducive to the proliferation of AHS vectors (DAFF 2017). The disease is not contagious, but is transmitted by *Culicoides midges*, which become infected when feeding on other infected animals. It is thought that most horses become infected in the period associated with sunset and sunrise, when the midges are most active. Depending on climatic conditions, outbreaks start first in AHS-infected areas each year and progress to the south and western part of the country (DAFF 2017). Between 1st September 2012 and 31st August 2017, South Africa recorded 2609 outbreaks of AHS. Gauteng consistently records the highest number of AHS cases in each season (DAFF 2017).

1.1.1 Outbreaks in the AHS controlled area and the EU current ban on direct export of horses from South Africa to EU

An outbreak of AHS in the AHS controlled area of South Africa was first reported in 1999. As per the terms of the 1997 EU Commission Decision that allowed the importation of horses directly from SA into the EU for the first time since 1968, the outbreak resulted in the suspension of imports of horses into the EU from South Africa for a period of at least 2 years after the last case recorded outbreak. Exports resumed in 2001. However, in 2004 there was another outbreak of AHS within the AHS Controlled Area that also resulted in the suspension of imports of horses from South Africa, and another in 2006. Despite outbreaks of AHS in 1999, 2004 and 2006 in the AHS controlled area, direct exports of horses to Europe and other AHS free destinations in the world were possible (Sergeant et al. 2016). In 2011, there was a fourth outbreak of AHS in the AHS Controlled Area. Following the 2011 outbreak, the EU instituted a ban on direct exports and further outbreaks in the area were recorded in 2013, 2014 and 2016 (Grewar et al. 2019) and now in 2021(Western Cape Government 2021). Following the 2011 outbreak, the European Union stated that they would only consider the lifting of this suspension following an audit by their Food and Veterinary Office (FVO) that would be conducted at least 2 years after the last reported case of the outbreak. This was subsequently conducted in 2013 and a number of issues were identified (see https://ec.europa.eu/food/audits-analysis/act_getPDF.cfm?PDF_ID=10679). In 2018, two years after the last outbreak, South Africa requested that the FVO schedule an audit to review the suspension that had been in place since 2011. This audit was scheduled for April 2020 (Hobday 2020). Due to Covid-19 restrictions, the audit could not take place and a new date needs to be negotiated. Currently, Mauritius and the United States of America are the only countries which are approved to export horses to the European Union, and have protocols in place to import horses from South Africa. These two export routes are the only two options, that South Africa can rely on to export horses to the European Union, while it addresses the issues related to the suspension of direct imports from South Africa. Whilst the OIE Code Chapter on AHS has included conditions under which Member Countries can consider the importation of horses from AHS-infected countries since the early 1990s, only the European Union has introduced conditions that approve the import of horses from South Africa. The condition of the audit imposed by EU falls within a specific chapter in the OIE Terrestrial Animal Code that provides guidelines on conditions under which member countries should import equids dependent on the AHS status of the exporting country. Therefore, until South Africa complies with the pending audit and the bilaterally agreed upon conditions with EU, the lifting of the ban on direct export of horses from South Africa to the EU, remains just an aspiration.

1.2 Current control measures and implications for trade

AHS is classified as a state-controlled disease in South Africa in terms of the country's Animal Diseases Act (Act No. 35 of 1984), thereby empowering the state to implement control measures. According to the Animal Diseases Act, 1984 (Act no 35 of 1984) all horses suspected of AHS must be reported to the state veterinary authority. In addition, official equine necroscopy examination is mandatory for all equines that die due to AHS. All horses in the infected area, and AHS protection zone, must be vaccinated against AHS annually. However, for horses in the free and surveillance zone, owners are compelled to obtain prior permission for vaccinating. Movement of horses into the AHS controlled area, and to a zone of higher control within the AHS controlled area, is subject to state veterinary control. The AHS controlled area is considered a low risk for AHS and is made up of three zones; AHS protection zone, AHS surveillance zone and the AHS free zone (Figure 1). Furthermore, the EU surveillance requirements dictate a serological test for AHS virus, every month, for at least 60 identified non-vaccinated horses distributed throughout the free and surveillance zones.

As mentioned previously, AHS is an OIE "listed" disease and the OIE Terrestrial Animal Code has a specific chapter that provides guidelines for conditions under which member countries can import equids dependent on the AHS status of the exporting country. These recommendations include provision for safe importation of equids from infected zones or countries through a combination of pre-export quarantine in a vector-protected quarantine facility and either serological or agent-identification testing while in quarantine. Consequently, since the 2011 ban, horses destined for the EU have to spend 21 days in vector-protected pre-export quarantine in Kenilworth, followed by a 90-day residency period in Mauritius, with the last 40 days in vector-protected quarantine on the island. Horses destined for countries like Dubai or Hong Kong cannot move directly from Mauritius – they have to spend a further 30 or 60 days in the EU, depending on the requirements of the final destination country (Ryan 2019). This export route comes with additional and considerable cost and can take up to six months. The time and route via a third country affects the health of the horses, as it is almost impossible to maintain fitness during long quarantine periods.

Although implementation of the SPS measures is to facilitate safe trade and movement of goods, studies in the agro food industry have found that adherence to the NTMs adds additional cost to

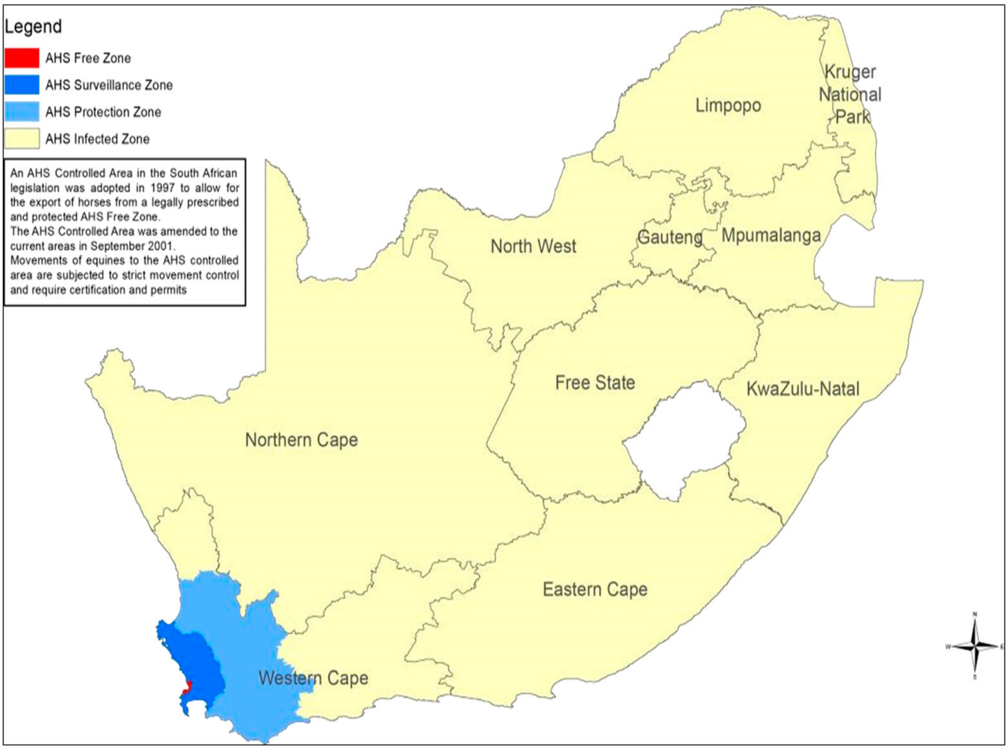


Figure 1. South African AHS zones within the AHS control area. The rest of the country highlighted in yellow is the AHS-infected area. Sourced from DAFF (2015).

exporters (Liu et al. 2019; Santeramo and Lamonaca 2019; Schuenemann and Kerr 2019). For example, Schuenemann and Kerr (2019) indicate that compliance with the EU's sustainability criteria for biofuels by sugar cane producers in Malawi have the potential to increase costs or provide insurmountable structural NTM's to biofuel production in Africa. Santeramo and Lamonaca (2019) reported that NTMs lock out African exporters from higher profits in destination markets. Similar sentiments are shared by the South African horse industry that the current ban is limiting the growth and export potential of the horse industry in South Africa.

1.3 Overview of the South African horse industry

The horse population in the country is estimated at 300,000 (Hobday 2017) and their use includes, but is not limited to, providing transport and working as draught animals in rural communities, crime fighting and performing security duties in the police and military forces, and a large leisure horse industry which includes performance at shows, racing and human companionship. Due to these varying activities, horses have a large commercial value attached to them. Prices may differ considerably according to the type of breed and the intended use. A good competing sport horse could sell for more than R1million (Hobday 2017).

The horse industry in South Africa is one of the most economic diverse industries as it bridges several government departments, including the Department of Agriculture, Land Reform and Rural Development (farming, breeding and disease control); the Department of Science and Innovation (research and diagnostic development and services); the Department of Sports, Arts and Culture and the Department of Trade and Industry. This industry, therefore, plays an important role in the South African economy, as many of the components are labour intensive activities.

Recent statistics suggest that the horseracing industry employs in excess of 177,000 people, through direct employment and indirect jobs providing services to racing and breeding (Ryan 2019). Gambling is a spinoff of horseracing as a sport. It is estimated that about R9 billion in South Africa is bet on horseracing a year (Racing SA 2019). The horse industry is also a good generator of foreign income through exports and horse racing activities. For instance, the export of horses provides foreign exchange income of approximately R250 million/annum, with a potential for growth to over R1 billion/annum and significant job creation (Sanne 2019). Overall, the industry contributes over R2 billion annually to the country's GDP (Ngalonkulu 2018). It is estimated that horseracing contributed a total of R4.3 billion in taxes between 2002 and 2009 and made a cumulative input of R16.8 billion to GDP over the same period (Racing SA 2019). In 2019, South Africa's annual premier horse racing event (the Durban July) paid the winner R4.5 million (Rajgopaul 2019). While this study could not ascertain how much income is generated per horse in an international racing competition, it is understood that a similar league of the race in Dubai paid its winner around US$10 million as far back as 2013 (PMG 2013).

2. Selected review of literature on impact of NTMs on trade

Alternatively used to tariffs, NTMs are policy measures that are capable of transforming trade flows (UNCTAD 2012; Arita, Beckman, and Mitchell 2017). While a majority of empirical studies on the impact of NTMs on trade are either product or country specific, NTMs have been reported to have a two-fold role: trade catalysts (Cardamone 2011) or trade barriers (Dal Bianco et al. 2016; Arita, Beckman, and Mitchell 2017; Kang and Ramizo 2017; Liu et al. 2019; Santeramo and Lamonaca 2019). Few other studies, however, indicate mixed impact of NTMs on trade (Xiong and Beghin 2014; Kareem 2014; Melo et al. 2014; Beckman and Arita 2016). In their meta-analysis of existing literature on NTMs' impact on agriculture and food trade, Santeramo and Lamonaca (2019) found varied estimated trade effects based on types of measures, and geo-economic regions involved in the trade. For example, there was a higher magnitude of varied effects for measures imposed by the North on trade partners from the South compared to other geo-economic areas. In addition, Minimum Residue Levels (MRLs) as a form of NTM exhibited lesser magnitude of varied effects compared to other types of measures. NTMs through Technical Barriers to Trade (TBTs), may play a corrective role by reducing asymmetric information, while mitigating risks in consumption, improving the sustainability of eco-systems through Sanitary and Phytosanitary Standards (SPSs) and influencing the competition and the decision to import or export via application of non-technical NTMs (Santeramo and Lamonaca 2019). While NTMs include TBTs, MRLs and SPSs, given the context of our paper, the focus of the discussion is on sanitary and phytosanitary measures.

Even though the last few decades have seen progressive trade liberalisation, SPS measures have largely determined market access for agricultural products. Although the application of SPS measures is primarily aimed at ensuring food security and protecting public health and environment, they often have the potential to distort trade (Disdier, Fontagné, and Mimouni 2008; Kareem et al. 2015; Hoda, Rana, and Chahir 2016; Martin 2018; Santeramo and Lamonaca 2019; Schuenemann and Kerr 2019; Hong et al. 2019). The distortionary and trade-restrictive effects of SPS measures are among the most important reasons why SPS measures are increasingly addressed in regional and bilateral trade agreements (Murina and Nicita 2014). However, the actual effectiveness of trade agreements in addressing SPS measures is debatable, as literature has shown that SPS measures often have both restrictive and trade diverting effects. Positive impacts of SPS measures have been reported where these may provide benefits not just to domestic consumers, but also foreign suppliers by enhancing their ability to gain greater market access for their agricultural products (Van der Meer 2014). On the other hand, SPS measures have been found to impede, specifically, the ability of developing countries to export agricultural and food products to developed countries (Disdier, Fontagné, and Mimouni 2008; UNCTAD 2014; Kareem et al. 2015; Hoda, Rana, and Chahir 2016; Martin 2018; Santeramo and Lamonaca 2019; Schuenemann and Kerr 2019). UNCTAD (2014) estimates the overall distortionary impacts of SPS measures in agricultural exports to the EU from low-income countries at approximately 14% of their total exports. Overall, literature revealed that as the number of exports by African countries to developed countries increases, the number of SPS measures against Africa become more stringent. Therefore, compliance by developing countries to these measures is very critical for entering markets in developed countries.

Beghin and Schweizer (2021) discuss evolution in composition of agricultural trade costs over time and note that NTMs and transportation costs remain a high proportion of total costs. They define transportation costs as constituting freight, policies and insurance and posit that they have been neglected in existing studies, despite the fact that policies at the source and/or destination can have a distortionary effect on the range of transport options available in trade and the costs thereof. They also encourage the disaggregation of transportation costs into national and international components in trade analyses.

The EU is one of the trading partners associated with more trade restrictive SPS measures than any other OECD (Disdier, Fontagné, and Mimouni 2008; Murina and Nicita 2014). These stringent trade restrictive measures act as an important market access barrier because compliance with such standards requires production processes and quality controls that are not easily available on a cost-effective basis in many developing countries (Murina and Nicita 2014). Furthermore, Murina and Nicita (2014) estimate that the EU's trade distortionary effect reduced lower income countries' agricultural exports to the EU by about 14% of the agricultural trade. However, other studies revealed that it is not always the case that SPSs limit trade (Kareem, 2014; Melo et al. 2014; Beckman and Arita 2016; Santeramo and Lamonaca 2019). Overall, NTMs may influence the competition and the decision to import or export. Similarly, one might expect that successful compliance by South Africa to the EU imposed SPS measures that led to the current ban on direct horse exports could present South Africa with an opportunity to negotiate successfully with other trade partners and expand their markets.

3. Theoretical approach and framework for analysis

Empirical research on economic analysis of the impact of NTMs has largely been conducted on trade levels focusing on the forgone trade. Most common methods used include inventory price comparison and quantity impact using gravity estimation through the use of either log linear least squares (Disdier, Fontagné, and Mimouni 2008; Hoda, Rana, and Chahir 2016; Kang and Ramizo 2017; Liu et al. 2019), Poisson pseudo maximum likelihood (Murina and Nicita 2014; Dal Bianco et al. 2016; Santeramo et al. 2019) or Heckman model specifications (Helpman, Melitz, and Rubinstein 2008; Disdier and Marette 2010; Xiong and Beghin 2014). However, NTMs and their inherent economic and welfare effects are not easily quantified (van Tongeren, Beghin, and Marette 2009; Fugazza 2013). The main challenge is the question of the correct baseline or point of reference often experienced when measuring the cost of compliance.

This paper seeks to investigate the financial burden of the current SPS measures imposed by the EU on the South African horse industry, specifically the movement of horses from South Africa to the EU via a third country and the associated quarantine measures. Literature suggests that product-specific regulations, such as maximum residue levels, hamper trade (Disdier and Marette 2010). Product-specific measures provide a comprehensive welfare analysis of NTMs and are usually examined using cost–benefit analysis (Disdier and Marette 2010). This approach quantifies costs and benefits streams for various economic actors, permitting additional custom-made evidence-based handling of specific NTMs. One distinct advantage of the cost–benefit analysis is that it expands the analysis to cover the cost or benefit associated with not having the measure in place. Due to the risk features of complying with the stipulated SPS measures by the EU, this paper applied cost–benefit analysis using stochastic scenario analysis to estimate the financial burden of SPS

Table 1. Input data and probability distribution used to model the potential cost of AHS with regard to trade.

Input name	Distribution	Sources
Local (SA) pre-screening and movement costs to pre-export quarantine	Pert (6200; 14,000; 18,500)	Informed data from: ARC-OVR, SAEHP, Kenilworth Quarantine station
Local (SA) quarantine costs for export via Mauritius (21 days)	Pert (33,000; 33,500; R33,600)	
Local (SA) quarantine costs for export directly to the EU (40 days)	Pert (43,830; 48,700; 53,570)	
Local (SA) free zone residency costs for export directly to the EU (20 days in addition to 40 days quarantine above)	Pert (4500, 5000, 5500)	
Freight from CT to Mauritius	Pert (69,749; 77,499; 85,249)	
Freight from Mauritius to the EU	Pert (138,218; 153,576; 168,933)	
Export travel costs from CT directly to the EU	Pert (135,000; 150,000; 165,000)	
Third country quarantine and residency costs (90 days)	Pert (83,187; 92,430; 101,673)	

measures on exporting a horse to the EU. In addition, Monte Carlo simulation was applied using probability distributions to incorporate the potential risk of uncertainty. The cost of exporting a horse directly from South Africa to the EU was used as a point of reference. Hong et al. (2019) used a similar approach to determine phytosanitary regulation effects on Washington apple producers under an apple maggot quarantine programme.

4. Methodology

4.1 Data collection

Data on export requirements, transport, quarantine, pre-screening, and testing costs, were obtained from the South African Equine Health & Protocols NPC (SAEHP), Agricultural Research Council_Ondersterpoort Veterinary Research (ARC-OVR) and the OIE Terrestrial Animal Health Code (2018). The nature of the data from each source is detailed in Table 1. Additional information on the epidemiology and outbreaks of the disease were collected from ARC-OVR, peer-reviewed journals and media releases and reports from the industry. Overall, all cost data was received from the horse industry and related stakeholders.

4.2 Setting of scenarios

Two scenarios were considered to enable the estimation of the financial burden of exporting a horse from South Africa to the EU (Figure 2). They are: Scenario 1 which supposes the export of horses via transit through a third country (Mauritius), and Scenario 2 which supposes the export of horses from South Africa directly to the EU.

If the owner's stable is situated in an AHS high risk area, a stopover period and testing is required enroute to the Kenilworth quarantine station for both Scenario 1 and Scenario 2.

4.3 Application of Monte Carlo simulation model on data for export cost/horse

Most of the estimated cost data received from the industry were based on 2018 prices. These data were incomplete or uncertain, in a form of ranges from minimum to maximum value. An average of the minimum and maximum values was estimated to determine the most likely value. Empirical distributions were then used on a stochastic spreadsheet model that was developed for the economic analyses using @Risk software for Excel version 7.5 (Palisade Corporation, Newfield, NY, USA). A PERT distribution was applied to model the costs. The distribution was chosen, as it is widely used in risk analyses, to represent the uncertainty of the value of some quantity where there is a reliance on subjective estimates. The distribution, which is a family of continuous probability distributions and a

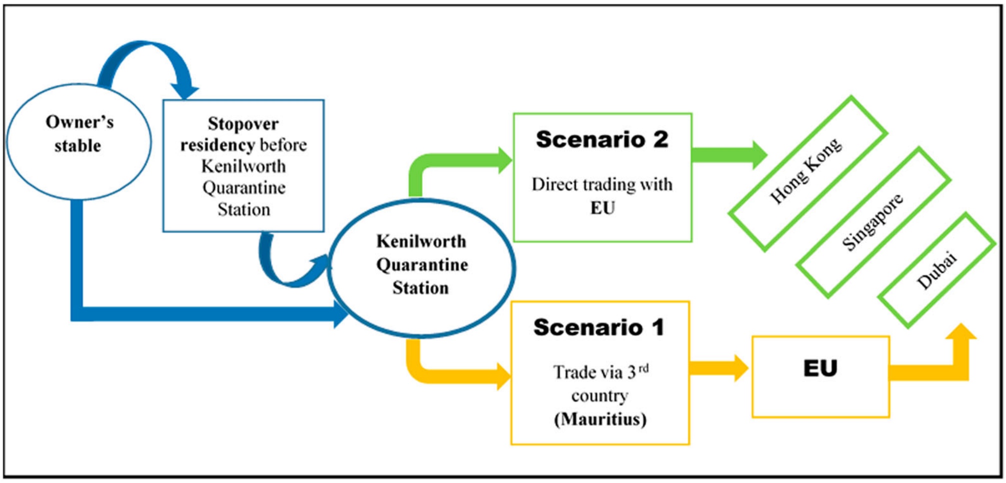


Figure 2. Mapping of scenarios for South African horse-trading routes.

direct alternative to a Triangle distribution is defined by the minimum, most likely, and maximum values that a variable can take. In addition, the distribution is used exclusively for modelling expert estimates (Vose 2008). The distribution permitted modelling of costs and generation of descriptive statistics.

4.4 Estimation of total export cost per horse to EU

Cost data were categorised into local travel costs, local and international quarantine, and international travel costs. Beghin and Schweizer (2021), encourage the disaggregation of transport costs in an analysis of NTM effects on trade. Although exporting via a third country (Mauritius), is currently the only option for exporting horses from South Africa to the EU, the costs are expectedly considerably higher than exporting directly to the EU. Total export cost directly to the EU as well as *via* a 90-day residency and quarantine in Mauritius were estimated using the formula:

$$XC_{dirEU} = QC_L + ITC + \varepsilon \quad (1)$$

$$XC_{viaMRTS} = QC_L + ITC_{MRTS} + QC_{MRTS} + ITC_{MRTStoEU} + \varepsilon \quad (2)$$

where XC = export costs including export permits; C = quarantine costs including local transit where applicable; ITC = international travel costs; ε = error term; Subscripts $_L$ indicate local, $_{MRTS}$ is Mauritius and $_{MRTStoEU}$ is Mauritius to EU route, $_{dirEU}$ represents direct route to EU, and $_{viaMRTS}$ is via Mauritius route.

After all uncertain data was integrated as distributions, a Monte Carlo simulation model was run with 5000 iterations. The scheduling of pre-export tests is precise, and the results of the tests are valid for a certain number of days in relation to the date of export. The simulation was based on the best-case scenario accounting for any uncertainties at 10%.

The impact of uncertain input values on total export costs was evaluated using the in-built @Risk stress analysis tool. The tool was used to visualise how the total export costs were affected when one or more of the most influential inputs were restricted to certain ranges. Stress analysis was then set up to monitor total export costs when export travel costs, transit quarantine costs and local quarantine costs were to be above the 95th percentile. These inputs were viewed to be most influential on the total cost of exporting a horse to the EU. The inputs were changed one by one while all others were held constant.

4.5 Estimation of benefits of controlling AHS on trade

The difference between export costs "with" and "without" the transit via a third country (nett cost) was valued to be the benefit of controlling AHS outbreaks. The general benefit of transiting via a third country is that it helps the SA horse industry to maintain trade with EU nations and subsequently with other countries. However, the option can only be regarded optimal if it improves the situation without worsening the current practice. Thus, nett benefit (*NB*) of preventing and controlling AHS was estimated as follows:

$$NB = XC_{viaMRTS} - XC_{dirEU} + \varepsilon \tag{3}$$

Given that uncertainty and variability exist in costs, an advanced sensitivity analysis was further conducted to evaluate how the distribution of estimated benefits were affected when total export cost via a third country were fixed at one of seven of its percentiles. Results of the sensitivity analysis will assist the decision makers to get an idea of how sensitive the current solution chosen by trade partners is, should there be any changes in the input values of one or more parameters of the total cost to the EU via a third country. Sensitivity analysis was applied using the formula:

$$(PSA) = n \times k \ \text{ matrix of parameter values} \tag{4}$$

where *PSA* is the probabilistic sensitivity analysis; *n* is the number of simulations; *k* is the number of parameters to be varied.

5. Results and discussion

5.1 Descriptive statistics

Before the empirical analysis was conducted, few statistical inference procedures were evaluated. Characterisation of the export cost/ horse was done using descriptive statistics as illustrated in Table 2. An enormous gap was established between minimum and maximum values for the total export cost/horse to the EU when comparing the direct and the via stopover route. This was due to additional transport and the 90-day third country quarantine and residency costs incurred when exporting via a stopover**.**

A standard deviation was considered to gauge how risky it is to export a horse to the EU. For both export routes, the standard deviation was found to be low around 3%, implying that the export cost per horse fluctuates marginally for both routes. This could assist horse owners to determine the current minimum required return on exporting a horse to the EU via the stop over. A negative skewness (–0, 02) was observed for the stopover route suggesting that horse owners may expect regular small gains and a few large losses. Kurtosis was estimated to measure financial risk. Kurtosis for exporting a horse either direct or via stopover was found to be small at less than 3 at 2.52 and 2.76, respectively, signalling a moderate level of risk as the probabilities of extreme costs are relatively low.

Table 2. Descriptive statistics of total costs per horse exported.

	Export route from RSA to EU	
Description	Direct to EU	Via stopover (MRTS)
Minimum (R)	203,208.44	351,478.43
Maximum (R)	240,776.67	399,917.63
Mean (R)	222,200.00	375,504
Mode (R)	223,576.09	376,037
Median (R)	222,119.00	375,498
Std Dev. (R)	6256.57 (2.6%)	7750 (1.9%)
Skewness	0.02	–0.02
Kurtosis	2.52	2.76
Conversion rate ZAR to \$ = 0.0751, 2018 Mid ER		

5.2 Cost of exporting a horse to the EU

Results show that there is a significant difference in the costs of the two scenarios considered (Figure 3). It is more costly to export horses from South Africa to the EU via a third country (Mauritius), the cost per horse ranged from a minimum of R351,478 ($24,954) to R399,917 ($28,397) compared to the minimum of R203,209 ($14,427) to a maximum of R240,776 ($17,095) for the direct export route. Similar distortionary effects of NTMs on African agri-food trade have been reported (Dal Bianco et al. 2016; Arita, Beckman, and Mitchell 2017; Kang and Ramizo 2017; Liu et al. 2019; Santeramo and Lamonaca 2019), particularly those imposed by the EU. Disdier, Fontagné, and Mimouni 2008; Murina and Nicita 2014). For instance, Murina and Nicita (2014) estimated that "considering all agricultural products, the additional trade distortionary effect of the European Union SPS measures is quantified in a reduction of lower income countries' agricultural exports of about 3

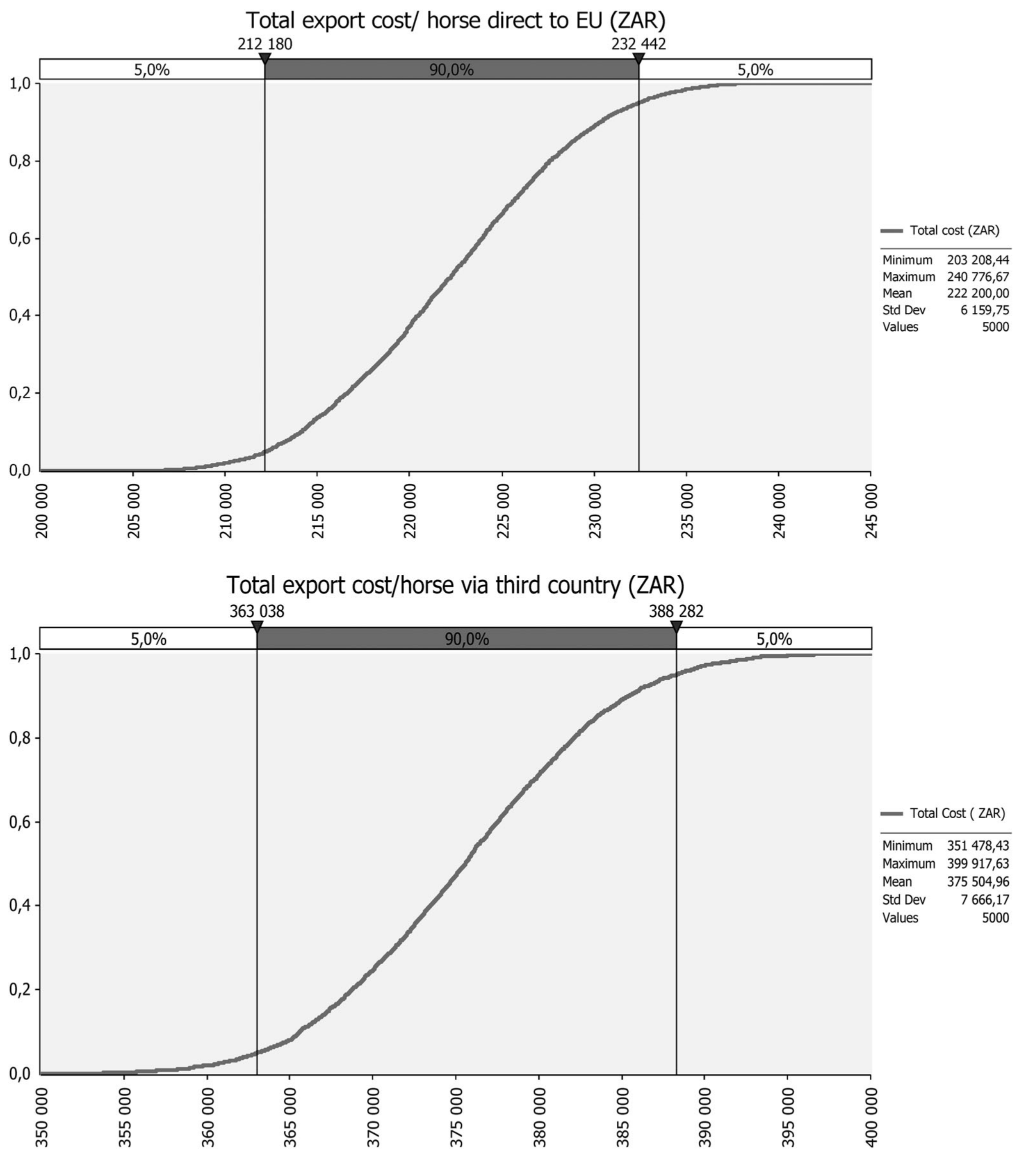
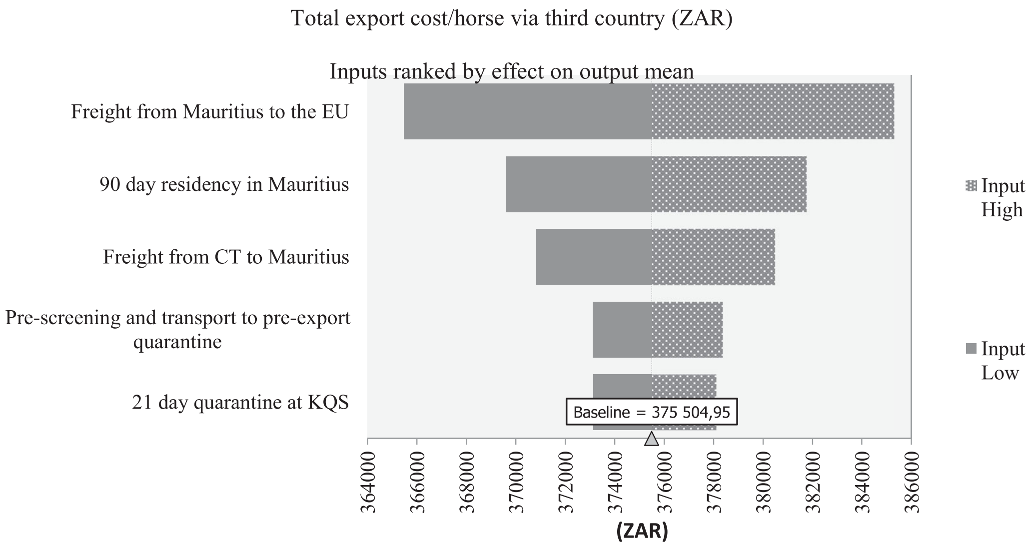


Figure 3. Total export cost/ horse from South Africa to EU.

billion $US, representing about 14% of the total agricultural exports of these countries to the EU". In addition, live animals and products are among product groups that have large numbers of SPS measures (Kang and Ramizo 2017).

The main drivers of costs for export via a third country are international export travel costs followed by 90-day residency and freight costs from Cape Town to Mauritius (Figure 4). For the direct export scenario, international export travel costs followed by local quarantine costs and pre-screening and movement to the pre-export quarantine were the main drivers of costs. This concurs with the assertion of Beghin and Schweizer (2021) that a transportation and NTM compliance cost constitutes a large proportion of trade costs, and has distortionary effects on trade. Hong et al. (2019) reported similar findings, where trade regulation of invasive species that required



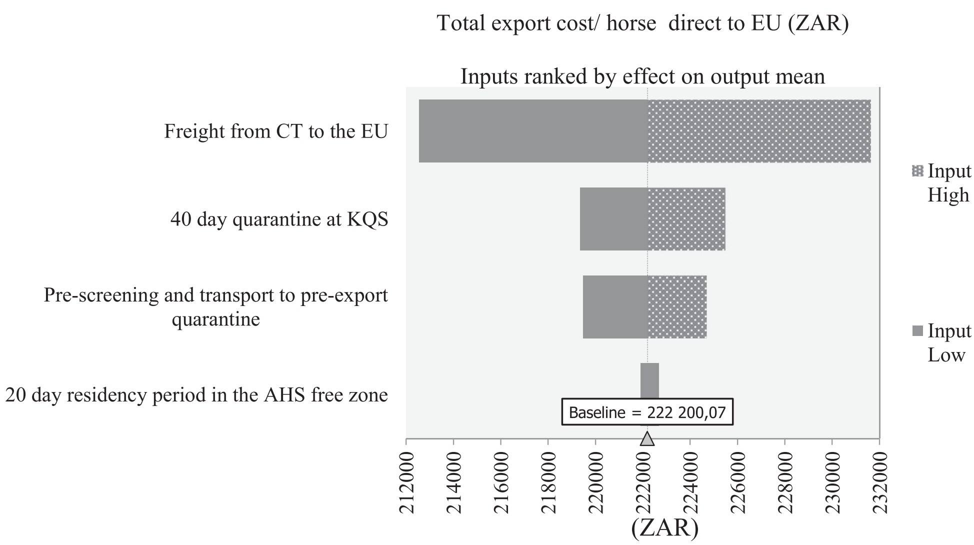


Figure 4. Main drivers of export cost/ horse from South Africa to EU.

a 40-day cold storage period for fresh apples shipped from quarantine areas caused additional economic losses compared to those estimated in the baseline scenario.

Stress analysis on the total cost of exporting a horse via a third country revealed the mean cost for the baseline scenario at R375,505 ($26,660) as illustrated in Table 2. When inputs were changed one by one, the cost of exporting a horse via a third country ranged between R345,952.99 ($24,562) to R399,883 ($28,391) while that of exporting a horse directly to the EU ranged between R200,654 ($14,246) to R240 559 ($17,079) as indicated in Table 3. The analysis further revealed that if freight costs from Mauritius were reduced by 5%, the maximum cost of exporting a horse via a third country would reduce the 95th percentile by 3.88% from the baseline. As regards to export cost per horse direct to the EU, reducing freight costs from Cape Town to the EU by 5% would reduce the 95th percentile by 7.17% from the baseline. Overall, stress analysis revealed that exporting a horse via a third country was not cost effective. This necessitates a speedy resolution of the EU ban on direct exports of horses from South Africa to the EU and other AHS free countries.

5.3 Benefit of controlling AHS on trade

The EU imposed ban on direct imports of horses from South Africa necessitated an export protocol via a third country (Mauritius). The difference between the mean total export costs for direct shipment to the EU and via a third country was estimated to be the trade benefit of controlling outbreaks

Table 3. Results of stress analysis on major cost drivers of exporting a horse to EU.

Scenario 1: Export costs via a 3rd country (ZAR)				
	Baseline	Freight from CT to Mauritius	90-day residency in 3rd country	Freight from Mauritius to the EU
Mean	375,505.00	369,905.87	368,827.09	364,409.36
5th percentile	363,127.03	358,345.33	357,575.67	356,075.212
95th percentile	387,990.56	381,592.74	380,151.61	372,941.18
Minimum	350,777.52	347,185.92	345,952.63	347,161.82
Maximum	399,883.22	391,395.72	389,806.83	381,186.22
StdDev	7573.96	7039.11	6824.83	5114.64
Percentage change from baseline (%)				
Mean		−1.49	−1.78	−2.95
5th percentile		−1.32	−1.53	−1.94
95th percentile		−1.65	−2.02	−3.88
Scenario 2: Export costs direct to the EU (ZAR)				
	Baseline	Pre-screening & transport to pre-export quarantine	40-day quarantine at KQS	Freight from CT to the EU
Mean	222,200.10	218,948.92	218,681.61	211,362.78
5th percentile	212,172.54	209,222.95	209,051.31	206,863.56
95th percentile	232,533.19	228,786.99	228,475.24	215,870.86
Minimum	202,451.73	200,654.90	201,705.40	201,367.96
Maximum	240,559.73	235,866.36	236,037.44	219,756.78
StdDev	6177.53	5968.22	5907.18	2746.48
Percentage change from baseline (%)				
Mean		−1.46	−1.58	−4.88
5th percentile		−1.39	−1.47	−2.50
95th percentile		−1.61	−1.75	−7.17

Conversion rate ZAR to $=0.0751, 2018 Mid ER

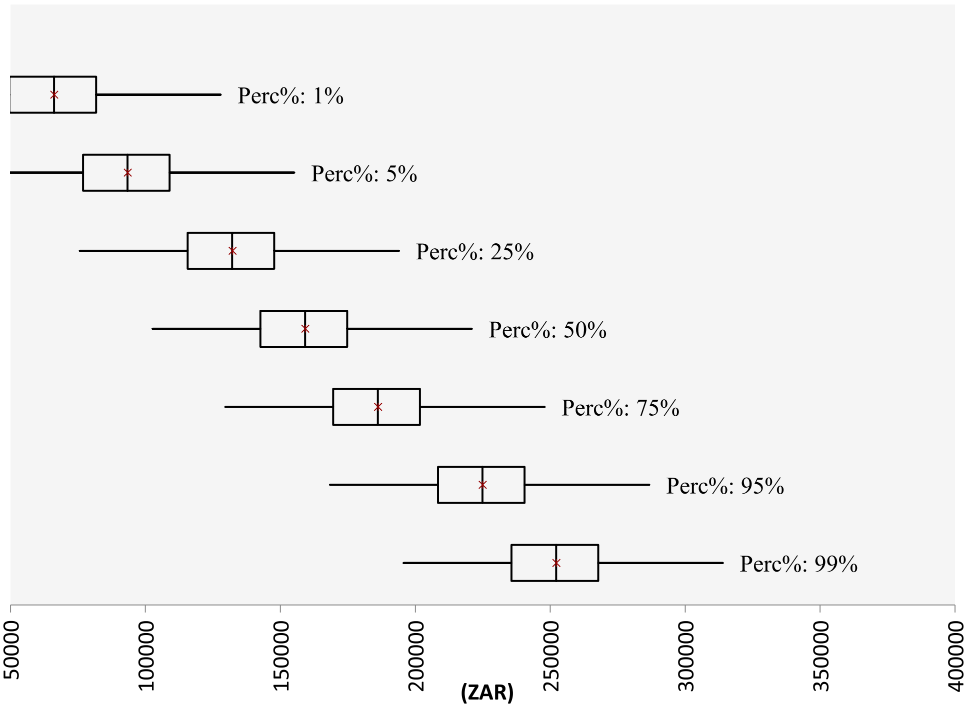


Figure 5. Box plot of net benefits for changing values of export cost via third country.

of AHS. The benefit of controlling AHS on trade was estimated between R148,275 ($10,527) and R164,938 ($11,299) per horse. Results of the advanced sensitivity analysis showed that if the total export costs via a third country are set at the lowest quantile, the distribution of nett benefits will be acceptable compared to the highest percentile (Figure 5). Hong et al. (2019) reported similar findings where the increase of storage costs by 10% resulted in an equivalent of 28% decrease in profits compared to the baseline-estimated profit.

6. Conclusions

As characterised by Jaffee and Henson (2005) administrative and technical capacities for food safety and agricultural health management are embodied in institutional structures and procedures, physical infrastructure, and human capital. However, a number of broader issues such as investment, climate, and governance affect the effectiveness and efficiency of the SPS controls. Compounding the trade restricting impact of NTMs is that, in many developing countries SPS authorities are under-resourced, lacking cost-effective production processes and quality controls required by their trading partners, specifically from developed countries. It, therefore, becomes paramount for WTO members, where possible, to take stock and ensure that their SPS measures serve their intended purpose. This will assist in avoiding unnecessary trade-impeding regulatory outcomes.

Analysis revealed that compliance to existing SPS measures by exporting a horse via a third country is 1,67 times more costly than exporting directly to the EU. The source of the financial burden of AHS in the industry is premised on two forms; long quarantine days both locally and internationally, as well as export costs associated with the transit via a third country. Simulation results of the total export cost via a third country confirm the importance of disease control measures to address incidences of AHS in the country; failure will continue to cost the industry heavily. Stress and sensitivity tests were conducted to confirm the reliability of the analysis. No matter how much the cost of the individual input is reduced, exporting via a third country is not an optimal option when compared to exporting directly, confirming the industry's assertions. While the analysis only focused on financial trade losses and did not cover other related socio-economic implications of the AHS outbreaks due to lack of data, the results of this study will provide the industry stakeholders with a basis to assess the losses against the costs of disease control. Given the economic importance of the industry to the national and local economies, the findings of this study suggest that the risk of recurrence of AHS in the controlled free zone should be kept at minimum levels by preventing any practice that would increase this risk. For the industry whose profitability relies more on export markets, addressing pertinent AHS control measures to maintain the integrity of the AHS controlled area is crucial for negotiating reinstatement of EU import protocols, benefitting many stakeholders and ensuring the economic profitability of the industry. Therefore, speeding up the undertaking of the pending, much needed, audit by the EU's FVO is recommended to ensure that the industry conforms to the audit outcomes. Undertaking of the audit could also assist the industry in facilitating the development of well-targeted technical assistance needed to overcome the cost of compliance to the SPS measures. In the short-term, the industry could explore ways of reducing the costs of transportation locally and internationally along the trade route.

The high magnitude of costs associated with exports via a third country, implies that any investment in research and development for AHS will yield benefits for South Africa in the short to medium and long term. Immediate measures required could include increased investment in movement control and surveillance to avoid another outbreak of AHS in the AHS controlled zone. A strengthened public-private sector partnership is recommended to work together to identify the most efficient and effective ways to develop capacity that will result in collaborative judicious investment to assist stakeholders in building a resilient horse industry that will lead to economic growth and the creation of additional job opportunities. Studies such as this current one, which quantify the costs of AHS, will provide decision makers with concrete economic arguments about the potential benefits of investing in the prevention and control of the disease. The methodology used for analysis in this paper can be applied to similar problems in other trade studies in South Africa and has the potential to be applied in the field of animal health economics.

Acknowledgements

The authors of this paper would like to thank the SAEHP (South African Equine Health & Protocols), particularly Dr Beverly Parker for providing information and data that permitted the undertaking of this study, and extensive review of this manuscript. The authors would also like to extend their gratitude to the two anonymous reviewers whose comments helped in shaping the final direction and output of this paper.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Petronella Chaminuka http://orcid.org/0000-0001-8644-4611

References

ARC-OVR (Agricultural Research Council-Ondersterpoort Veterinary Research). 2018. *Diagnostic services programme*. Pretoria.

Arita, S., J. Beckman, and L. Mitchell. 2017. Reducing transatlantic barriers on US-EU agri-food trade: What are the possible gains? *Food Policy* 68: 233–47.

Beckman, J., and S. Arita. 2016. Modeling the interplay between sanitary and phytosanitary measures and tariff-rate quotas under partial trade liberalization. *American Journal of Agricultural Economics* 99, no. 4: 1078–95.

Beghin, J.C., and H. Schweizer. 2021. Agricultural trade costs. *Applied Economic Perspectives and Policy* 43, no. 2: 500–30.

Cardamone, P. 2011. The effect of preferential trade agreements on monthly fruit exports to the European Union. *European Review of Agricultural Economics* 38, no. 4: 553–86.
DAFF (Department of Agriculture, Forestry and Fisheries). 2015. *South African AHS zones*. Pretoria: Directorate: Animal Health.
DAFF (Department of Agriculture, Forestry and Fisheries). 2017. *African horse sickness season report 1 September 2016–31 August 2017*.
Dal Bianco, A., V.L. Boatto, F. Caracciolo, and F.G. Santeramo. 2016. Tariffs and non-tariff frictions in the world wine trade. *European Review of Agricultural Economics* 43, no. 1: 31–57.
Dean, A.S., G. Fournié, A.E. Kulo, G.A. Boukaya, E. Schelling, and B. Bonfoh. 2013. Potential risk of regional disease spread in West Africa through cross-border cattle trade. *PLoS ONE* 8, no. 10: e75570. doi:10.1371/journal.pone.0075570.
Disdier, A.C., L. Fontagné, and M. Mimouni. 2008. The impact of regulations on agricultural trade: Evidence from the SPS and TBT agreements. *American Journal of Agricultural Economics* 90, no. 2: 336–50.
Disdier, A.C., and S. Marette. 2010. The combination of gravity and welfare approaches for evaluating non-tariff measures. *American Journal of Agricultural Economics* 92, no. 3: 713–26.
Fevre, E.M., B.M. Bronsvoort, K.A. Hamilton, and S. Cleaveland. 2006. Animal movements and the spread of infectious diseases. *Trends in Microbiology* 14, no. 3: 125–31.
Fugazza, M. 2013. *The economics behind non-tariff measures: Theoretical insights and empirical evidence*. UNCTAD policy issues in international trade and commodities study series no.57. Geneva: UNCTAD.
Grewar, J.D., C.T. Weyer, G.J. Venter, L.S. van Helden, P. Burger, A.J. Guthrie, P. Coetzee, et al. 2019. A field investigation of an African horse sickness outbreak in the controlled area of South Africa in 2016. *Transbound Emerg Dis* 66, no. 2: 743–51. doi:10.1111/tbed.13077.
Helpman, E., M. Melitz, and Y. Rubinstein. 2008. Estimating trade flows: Trading partners and trading volumes. *Quarterly Journal of Economics* 73, no. 2: 441–86.
Hobday, C. 2017. African horse sickness: The effect on South African exports. Power point presentation to the animal transportation association 43rd annual conference, February 8–11, Hong Kong. https://www.animaltransportationassociation.org/annual-ata-conference/2017-hongkong.
Hobday, C. 2020. *The FVO have finally allocated a date for the audit in South Africa*. Hobday Equestrian Enterprises. https://www.hee.co.za/fvo-have-finally-allocated-date-for-audit-in-south-africa/ (accessed November 24, 2020).
Hoda, E.E., H. Rana, and Z. Chahir. 2016. Do SPS measures matter for margins of trade? Evidence from firm-level data. *Applied Economics* 48: 1949–64.
Hong, Y.A., R.K. Gallardo, X. Fan, S. Atallah, and M.I. Gómez. 2019. Phytosanitary regulation on Washington apple producers under an apple maggot quarantine program. *Journal of Agricultural and Resource Economics* 44, no. 3: 646–63.
Jaffee, S.M., and S. Henson. 2005. Agro-food exports from developing countries: The challenges posed by standards. In Ataman, Aksoy, and John Beghin, eds. *Global agricultural trade and developing countries*, 91–114. Washington DC: The World Bank.
Kang, Jong Woo, and D. Ramizo. 2017. Impact of sanitary and phytosanitary measures and technical barriers on international trade. *Journal of World Trade* 51, no. 4: 539–73.
Kareem, O.I. 2014. Product standards and Africa's agricultural exports. Working Paper No. 0009. African Growth & Development Policy.
Kareem, F.O., Brummer, B. and Martinez-Zarzoso I. 2015. Food safety standards, compliance and European Union's rejection of African exports: the role of domestic factors. GlobalFood Discussion Paper No. 74. University of Gottingen. Gottingen.ed.
Liu, C., D. Lin, J. Liu, and Y. Li. 2019. Quantifying the effects of non-tariff measures on African agri-food exports. *Agrekon* 58, no. 4: 451–71.
Martin, W. 2018. A research agenda for international agricultural trade. *Applied Economic Perspectives and Policy* 40, no. 1: 155–73.
Melo, O., A. Engler, L. Nahuehual, G. Cofre, and J. Barrena. 2014. Do sanitary, phytosanitary, and quality-related standards affect international trade? Evidence from Chilean fruit exports. *World Development* 54: 350–9.
Melo (de), J. and Nicita, A. 2018. Non-tariff measures: Data and quantitative tools of analysis. Working Papers P218, FERDI.
Murina, M., and A. Nicita. 2014. *Trading with conditions: The effect of sanitary and phytosanitary measures on lower income countries' agricultural exports*. UNCTAD policy issues in international trade and commodities study series no.68. New York: UNCTAD.
Ngalonkulu, M. 2018. The South African horse industry: A potential billion-rand market. *Forbes Africa*. https://www.forbesafrica.com/economy/2018/04/10/south-africanhorse-industry-potential-billion-rand-market/. Racing South Africa, undated. Quick facts. https://www.safhorse.com/view_page.aspx?ID=73.
Nimenya, N., P.F. Ndimira, and B.H. de Frahan. 2012. Tariff equivalents of nontariff measures: The case of European horticultural and fish imports from African countries. *Agricultural Economics* 43, no. 6: 635–53.
PMG (Parliamentary Monitoring Group). 2013. Transformation in horse racing industry: Input by National Horse Racing Association, SA Grooms Association & Minister of Trade and Industry. National Horseracing Industry briefing: Status of transformation in the industry. https:/www./pmg.org.za/committee-meeting/16337/ (accessed May 15, 2019).

Racing South Africa. 2019. Industry development. Extract from the strategic analysis of the sport of South African horse-racing. https://www.safhorse.com/view_page.aspx?ID=652 (accessed April 10, 2019).
Rajgopaul, D. 2019. Here's how much you can win at the Vodacom Durban July. Business report/economy 06 July 2019. https://www.iol.co.za/business-report/economy/heres-how-much-you-can-win-at-the-vodacom-durban-july-28759955 (Accessed July 18, 2019).
Ryan, J. 2019. SA equine industry pushing for direct exports. *Farmer's Weekly* (South Africa), November 22. https://www.pressreader.com/south-africa/farmers-weekly-south-africa/20191122/281891595112568 (accessed November 24, 2019).
Sanne, I. 2019. Published scientific study confirms that the risk of exporting African horse sickness is negligible. *Equine Health Fund*. http://www.equinehealthfund.co.za/Portals/0/Risk%20Assessment.pdf.
Santeramo, F.G., and E. Lamonaca. 2019. On the impact of non-tariff measures on trade performances of the African agri-food sector. *Agrekon* 58, no. 4: 389–406.
Santeramo, F.G., E. Lamonaca, G. Nardone, and A. Seccia. 2019. The benefits of country-specific non-tariff measures in world wine trade. *Wine Economics and Policy* 8: 28–37.
Schuenemann, F., and W.A. Kerr. 2019. European Union non-tariff to imports of African biofuels. *Agrekon* 58, no. 4: 407–425.
Sergeant, E.S., J.D. Grewar, C.T. Weyer, and A.J. Guthrie. 2016. Quantitative risk assessment for African horse sickness in live horses exported from South Africa. *PLoS One* 11, no. 3: e0151757. doi:10.1371/journal.pone.0151757.
Shepherd, B. and Wilson, N. 2013. Product standards and developing country agricultural exports: the case of the European Union. *Food Policy*. 42:1–0.
Torres, A. 2013. Role of sanitary and phytosanitary measures within the context of free trade agreements. *Revista Colombiana de Ciencias Pecuarias* 26: 43–47.
UNCTAD. 2012. *International classification of non-tariff measures*. UNCTAD/DITC/TAB/2012/2. New York: United Nations.
UNCTAD. 2014. *Trading with conditions: The effect of sanitary and phytosanitary measures on lower income countries agricultural exports*. Policy issues in international trade and commodities research studies series no. 68.
Van der Meer, K. 2014. *Implementing SPS measures to facilitate safe trade: Principles and practice in Cambodia, Lao PDR, Philippines, and Thailand*. Standards and trade development facility working paper. Geneva: WTO.
van Tongeren, F., J. Beghin, and S. Marette. 2009. *A cost-benefit framework for the assessment of non-tariff measures in agro-food trade*. OECD food, agriculture and fisheries papers, no. 21. Paris: OECD Publishing. doi:10.1787/220613725148.
Vose, D. 2008. Risk analysis- a quantitative guide. 3rd edn. John Wiley & Sons, Chichester
Western Cape Government. 2021. *Situation report: AHS in Cederberg local municipality: 20 April 2021*. Cape Town: Animal Health.
WTO (World Trade Organisation). 1995. The WTO agreement on the application of sanitary and phytosanitary measures (SPS Agreement). https://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm (accessed March 6, 2020).
Xiong, B., and J. Beghin. 2011. Does European aflatoxin regulation hurt groundnut exporters from Africa? *European Review of Agricultural Economics* 39, no. 4: 589–609.
Xiong, B., and J. Beghin. 2014. Disentangling demand – enhancing and trade – cost effects of maximum residue regulations. *Economic Inquiry* 52, no. 3: 1190–1203.