View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Edinburgh Research Explorer

THE UNIVERSITY of EDINBURGH

Edinburgh Research Explorer

Livestock transportation: a model for ex-ante policy analysis

Citation for published version:
Baltussen, W, Rossi, R, Doorneweert, B, Vrolijk, H, Oudendag, D & de Smet, A 2010, 'Livestock transportation: a model for ex-ante policy analysis' Paper presented at 9th Wageningen International Conference on Chain and Network Management (WiCaNeM 2010), Wageningen, Netherlands, 26/05/10 - 28/05/10, .

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Other version

Publisher Rights Statement:
© Baltussen, W., Rossi, R., Doorneweert, B., Vrolijk, H., Oudendag, D., & de Smet, A. (2010). Livestock transportation: a model for ex-ante policy analysis. Paper presented at 9th Wageningen International Conference on Chain and Network Management (WiCaNeM 2010), Wageningen, Netherlands.

General rights
Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

OPEN ACCESS

Download date: 20. Feb. 2015

Livestock transportation: a model for ex-ante policy analysis

Willy Baltussen,[1] Roberto Rossi,[2] Bart Doorneweert,[1] Hans Vrolijk,[1] Diti Oudendag,[1] Annelise de Smet[1]

1. LEI, Wageningen University, the Netherlands

2. Logistic Decision and Information Science Group, Wageningen University, the Netherlands

Abstract

The protection of live animals during transport in the EU is currently regulated under the Council Regulation No. 1/2005. The current legal regime is strongly criticized by the European society. To reform the existing regulation, policy makers need insights into the impact of possible transport restrictions for live animals. In this work, we propose a mathematical programming model to assess the potential impact of a policy reform involving limitations of travelling times and space allowances. This model is implemented for the years 2002 and 2013. A sensitivity analysis is performed on variations of fuel prices and cost of meat transport.

Transport, Livestock, Mathematical Programming, Policy Analysis

1. Introduction

Europe has a long history of transporting livestock over long distances. Records from the XVI century show that about a quarter of a million oxen were traded on the continent each year (Gijsberts and Lambooij, 2005). Nowadays, about 300.000 loads involving 830 million animals (cattle, sheep, goats, pigs and poultry) are transported throughout the EU-27 each year. It is clear that such a market must be properly regulated and that rules being enforced must take into account a variety of stakeholder interests that encompass not only economical, but also ethical and health issues.

Due to cultural, philosophical, and religious differences between individuals, the definition of acceptable animal welfare conditions cannot be unique (Vanhonacker et al., 2008). Despite these differences the OIE has recommended a definition about animal welfare concerning transport[1]. Nevertheless, it is generally agreed that livestock should not undergo unnecessary suffering throughout their lifecycle, which includes breeding, transport, and slaughtering (EFSA[2]). Furthermore, it has been shown that livestock transport significantly affects animal welfare. The authors in Malena et al. (2007) point out that transport to a slaughterhouse is a stress-inducing situation for pigs and cattle that may lead to subclinical changes, clinical manifestations of poor health, and to death. They reported that an increase of transport distance has a positive correlation with the mortality rate during transport for pigs and cattle. In fact, the mortality rate ranged from 0.02% for calves transported less than 50 km up to 0.37% for young sows, adult sows and boars transported over 300 km. In Malena et al. (2007), the authors also reported a number of studies showing that a high livestock density on a truck is generally associated with a higher mortality rate (Lambooij and Engel, 1991; Perremans and Geers, 1996; Warriss, 1998).

Transport of live animals in the European Community is currently regulated under the Council Regulation (EC) No. 1/2005 (European Union, 2005). This regulation is based on the adoption of common provisions laid down in the “European Convention for the protection of Animals during international transport” (1968 and revised version 2003). In 2002 the Scientific Committee on Animal Health and Animal Welfare[3] evaluated the existing regulation for live animal transport. The Council recommended a policy revision on limitations of travelling times and space allowances. However, despite the recommendations received, the Council did not alter all the existing requirements as they were stipulated in regulation No. 1/2005. This is one of the reasons why the current regulations for animal transport are strongly criticized by both non-governmental organizations (NGOs), see Garcés et al. (2008) and Stevenson (2008), and politicians alike, i.e. see the EU parliament’s Animal Transport Debate CRE 15/01/2009 – 2[4]. Two recurring arguments underlie this criticism:

---

[1] OIE, 2006. Guidelines for the transport of animals by land. In Terrestrial Animal Health Code. Appendix 3.7.3; http://www.oie.int/eng/normes/mcode/en_chapitre_3.7.3.htm accessed on 31/10/2008.

[2] European Food Safety Authority (EFSA), 2004. “The welfare of animals during transport”. Scientific Report of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to the welfare of animals during transport. EFSA-Q-2003-094

[3] Scientific Committee on Animal Health and Animal Welfare (SCAHAW), 2002. The welfare of animals during transport (details for horses, pigs, sheep and cattle).
http://ec.europa.eu/food/fs/sc/scah/outcome_en.html

[4] EU Parliament, 2009. Animal Transport Debate, CRE 15/01/2009–2. Strasbourg.
http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+CRE+20090115+ ITEM-002+DOC+XML+V0//EN

firstly, current regulations are neither uniformly nor sufficiently imposed on all member states; secondly, the current regulations do not take into account scientific knowledge about animal welfare during transport of live animals. Nevertheless, in order to reform existing regulations, policy makers need insights into the economic consequences of the various proposed transport limitations for live animals. To the best of our knowledge there is no research available on the economic effects of animal transport regulations. Existing works are generally focused on different aspects. For instance, the authors in Ljungberg et al. (2007) and Gribrovskaia et al. (2006) explore route optimization strategies for minimizing animal transportation time and distances. Similarly, other existing works focus on optimizing business processes rather than exploring economic effects of limitations imposed by policy regulations on these processes.

In this work, we present a mathematical programming model, “TRansport of Animals and Meat” (TRAM), that can be used in order to obtain insights on the impact of different policy options for the transport of live animals. Cost-effectiveness analysis is an effective tool that can be used to select an appropriate set of policy options. Mathematical programming models are a good option for conducting this sort of analysis, in fact it is relatively easy to include technical and institutional data in these models. Our model is employed to assess the potential impact of a policy reform involving limitations of travelling times and space allowances. The assessment is carried on, in retrospective, for the year 2002 and, by using forecast data, for the year 2013. Furthermore, a sensitivity analysis is carried on in order to assess the stability of the results against variations of travelling times, fuel prices and cost of meat transport.

The paper is organized as follows. In Section 2 we introduce the problem of interest, we discuss the data sources that were selected and we describe the mathematical programming model that will be employed in order to assess different options for the revision of policy regulations. In Section 3 we introduce the potential policy revisions for which we will assess the respective impact. In Section 4 we present our impact assessment of the proposed policy revisions. In Section 5 we present the results of a sensitivity analysis we conducted for our model. In Section 6 we discuss the limits of our study and we suggest directions for future research. In Section 7 we draw conclusions.

2. Transport of livestock in the EU

In this work, we aim to assess the potential impact of a EU policy revision involving limitations of travelling times and space allowances in livestock transportation. More specifically, we want to analyze how the number of animals and the amount of meat transported on short and long distance vary in relation to specific EU policy restrictions. Furthermore, we also want to estimate the number of kilometers covered, since this information may be employed as an indicator of the environmental impact of different policy options.

Figure 1: European Union NUTS 1 regions

Data sources

In our work, a variety of data sources have been considered in order to collect the relevant data on livestock production, slaughtering and meat consumption. We adopted for our model the Level 1 Nomenclature of Territorial Units of Statistics (NUTS 1) (European Union, 2003), which divides the European Union in 97 regions (Fig. 1). Production and consumption data for these regions are obtained via the CAPRI model[5].

CAPRI is a global agricultural sector model with a focus on EU-27, Norway and Western Balkans. CAPRI uses EUROSTAT statistics, expert knowledge and calibration tools to estimate production at NUTS 2 level (about 250 regions) for different types of products and the consumption of 47 products at NUTS 0 (Member State) level. We considered the production figures from the CAPRI output at NUTS 2 level and we aggregated these in order to obtain data at NUTS 1 level[6] (97 regions). The consumption figures from CAPRI are at the level of Member States. The regional consumption on NUTS 1 level are estimated on the basis of the number of inhabitants per NUTS 1 region, by assuming that the consumption of meat within a Member State does not strongly differ. The years 2002 and 2013 are chosen because these are the years for which the output of the CAPRI model is calibrated.

In addition to production and consumption data, transport costs among NUTS 1 regions must be estimated. Our estimates of transport costs are based on expert knowledge, data from transport companies interviewed and geographical data from the Internet (distances between NUTS 1 regions, ferry connections etc.) via MS Virtual Earth®. The total costs for any transport is divided in drivers costs, fuel costs, truck costs, toll and ferry costs, overhead costs (central office, accountancy, administration), control posts and other costs ((bedding materials, disinfection). The interviews conducted revealed that total transport costs do not differ much per animal species, and that the total costs of live animals and meat deliveries are comparable, except for the use of control posts, i.e. resting place for animals. For this reason, in this research no distinction is made among delivery costs for different species, category of animals within species and meat. It is also assumed that all return freights are empty after a delivery. The transport costs are then represented as a matrix containing delivery costs from one NUTS 1 region to another region for all combinations of NUTS 1 regions.

Finally, slaughtering capacity must be estimated in order to assess the impact of specific policy restriction. This is estimated using EUROSTAT data[7] about the number of slaughters per species and country. The estimates take into account the fact that, given the monthly variation in slaughtering, the real capacity is higher than the figures from EUROSTAT. For Poland, Germany, France, Spain, Italy and the Netherlands insights in the regional distribution of slaughter capacity per species were obtained by interviewing experts.

Data on animal breeding and slaughtering, on costs of production and costs of slaughtering are gathered by literature search (Horne, 2009; VAS-ZAS[8]; Fowler[9]; Hoste et al., 2007;

[5] CAPRI Modeling System. http://www.capri-model.org

[6] For instance for the Netherlands this means that NUTS 2 level are the 12 Provinces, they aggregate into 4 NUTS 1 regions (Nothh, East, West and South Netherlands) and those NUTS 1 regions aggregate into The Netherlands as a NUTS 0 region.

[7] EUROSTAT. Meat production and foreign trade (annual data), 2008. http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database

[8] Verenigde Amsterdamse Slagersorganisatie - Stichting Zelfslachtende Amsterdamse Slagers (VAS-ZAS), 2009. Slaughtercosts per 1 Januari 2009
http://www.vas-zas.nl/zas/tarieven_abattoir

[9] Pig cost of production in selected countries for 2007, AHDB Meat Services, BPEX

Vermeij et al., 2007; EUROSTAT[10]). If no information on the aspects of a certain country was available, it is assumed that the data of an adjacent country is applicable.

The Transport of Animals and Meat model (TRAM)

TRAM has been developed as a regionalized (NUTS 1) mathematical programming model of the European transport of live animals and meat. Given the regional production and consumption within EU-27, and given transport and slaughtering cost data, the total costs of producing, transporting and slaughtering animals are minimized in order to meet the regional consumption of meat for each species (Fig. 2).

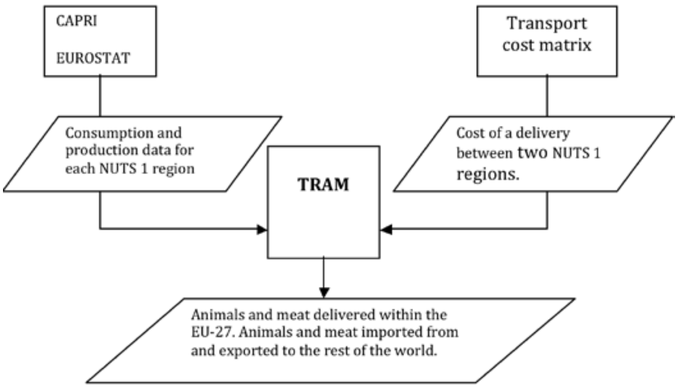

Figure 2: Data sources and output of the Transport of Animals and Meat model

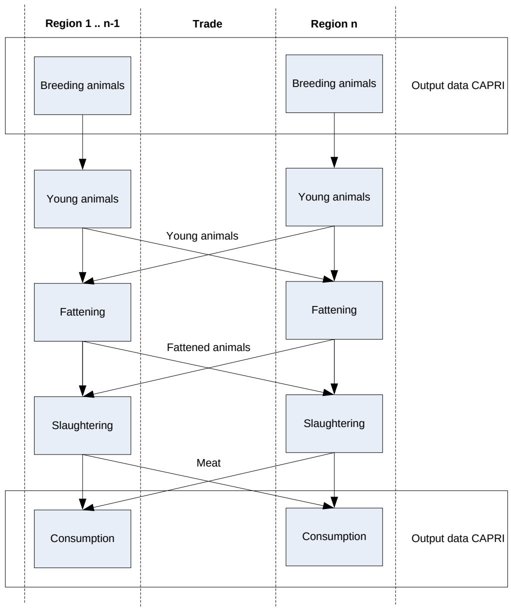

Figure 3: Overview of the Transport of Animal and Meat model (TRAM)

The regional consumption per species can be met either by transporting young animals for fattening, or by transporting fattened animals for slaughter, or by transporting meat from one region to another (Fig. 3).

In TRAM we distinguish three main sets of decision variables: $x_{i,j,k}$, $y_{i,k}$, and $z_{i,k}$. Indexes i, j identify NUTS 1 regions in the EU-27. Index k may identify young animals (where *Ya* denotes the set of all the possible young animal species), fattening animals (where *Fa* denotes the set of all the possible fattening animal species) and slaughtered animals, i.e. meat, (where *Ma* denotes the set of all the possible meat varieties) for any given species (*a*). In TRAM we report 4 animal species (cattle, pigs, poultry and sheep) and 18 products of these species. A decision variable $x_{i,j,k}$ represents transport of animals or meat, depending on the index k, from region i to region j; a decision variable $y_{i,k}$ represents meat transported from the rest of the world to region i (import); finally, a decision variable $z_{i,k}$ represents transport of meat from a region i (export) to the rest of the world. Is it assumed in our model that transport of live animals to and from the rest of the world is not allowed. Also in reality the number of live animals transported outside the EU-27 is small compared to all live animals transported and also compared to the number of animals transported on long distance. The unit of these

[10] Eurostat. Hourly labour costs, 2008.
http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home

variables is 1000 animals (for $x_{i,j,k}$ with $k \notin Ma$) or 1000 tons of meat (for $x_{i,j,k}$ with $k \in Ma$ and for $y_{i,k}$ and $z_{i,k}$).

The objective, in TRAM, is to minimize the total cost, which comprises costs for transport between NUTS 1 regions, transport cost of imported or exported meat, slaughtering costs and fattening costs. The objective function is therefore:

$$\min \quad \sum_i \sum_{k \in Ma} y_{i,k} Const + \sum_i \sum_{k \in Ma} z_{i,k} Const + \sum_i \sum_j \sum_k x_{i,j,k} tCosts_{i,j,k} +$$
$$\sum_i \sum_{k \in Fa} (eAniProd_{i,k} + \sum_j x_{j,i,k} - \sum_j x_{i,j,k}) SlCosts_{i,k} +$$
$$\sum_i \sum_{k \in Ya} (eAniProd_{i,k} + \sum_j x_{j,i,k} - \sum_j x_{i,j,k}) FatCosts_{i,k}$$

where:

i, j	= NUTS 1 regions in the EU 27
k	= transported young animals (Ya), fattened animals (Fa) or meat (Ma)
$Const$	= a constant value for transporting a unit of animal species from/to the rest of the world.
$eAniProd_{i,k}$	= production of animal species k per region i
$tCosts_{i,j,k}$	= cost for transporting a unit of animal species k between region i and j
$SlCosts_{i,k}$	= cost for slaughtering species $k \in Fa$ in region i
$FatCosts_{i,k}$	= cost for fattening a young animal species $k \in Ya$ in region i.

Negative quantities of transported animals and meat are not allowed:

$$x_{i,j,k} \geq 0 \qquad \text{for all } i, j \text{ and } k \qquad (2.1)$$

$$y_{i,k} \geq 0 \qquad \text{for all } i \text{ and } k \qquad (2.2)$$

$$z_{i,k} \geq 0 \qquad \text{for all } i \text{ and } k. \qquad (2.3)$$

The total incoming meat (production of meat, import of meat from outside the EU-27 and import from intra-trade of animals or meat) in any given region i should equate the output of meat (consumption of meat, export of meat outside the EU-27 and export to EU-27 regions). In equation 2.4 meat and fattened animals are taken into account because fattened animals can be converted in meat by slaughtering them. Such a conversion is captured in the model by the conversion factor TransVeck.

For $k \in Fa \cup Ma$

$$InputMeat_{i,k} = OutputMeat_{i,k}. \qquad (2.4)$$

This means

$$P_{i,k} + (y_{i,k} + \sum_{j,j \neq i} x_{j,i,k}) TransVec_k = C_{i,k} + (z_{i,k} + \sum_{j,j \neq i} x_{i,j,k}) TransVec_k$$

where

$P_{i,k}$ = production of meat of variety *k* (=Ma) in region i

$TransVec_k$ = conversion factor from animal to meat, if $k = Ma$ then $TransVec_k = 1$

$C_{i,k}$ = consumption of meat of variety *k* (=Ma) in region i.

Finally we impose the flow conservation constraint.

The number of animals produced in a country c, which comprises several regions, plus the imported animals, minus the export of animals cannot exceed the slaughter capacity of the country.

For $i \in c$, $k = Fa$

$$SlaughterCap_c \cdot Fact \geq \sum_i (eAni\Pr od_{i,k} + \sum_{j,j \neq i} x_{j,i,k} - \sum_{j,j \neq i} x_{i,j,k}), \qquad (2.5)$$

where

$SlaughterCap_c$ = slaughter capacity in 1000 animals

$Fact$ = factor to enlarge measured slaughter capacity

c = region at NUTS 0 level (member state).

The slaughter capacity at member state level is derived from EUROSTAT statistics[11], which report the number of animals slaughtered. This does not necessarily equal the slaughter capacity. The number of animals slaughtered can be increased, for instance, by using more work shifts. In addition, the variation in the number of slaughtering per month indicates the possibility to increase the slaughter capacity. Therefore, the slaughter capacity used in the equation is the number of animals slaughtered multiplied by a factor that was obtained by conducting a survey among experts in the area. The equation is at NUTS 0 level because, at this level, information about slaughter capacity is available. For Poland, Germany, France, Spain, Italy and the Netherlands additional information from regional experts was gathered to implement this equation on NUTS 1 level.

The number of animals produced plus the animals imported minus the animals exported cannot be negative in any given region i.

For $k = Fa$

$$eAni\Pr od_{i,k} + \sum_{j,j \neq i} x_{j,i,k} - \sum_{j,j \neq i} x_{i,j,k} \geq 0. \qquad (2.6)$$

In any given region i, the number of animals fattened should be equal to the young animals produced plus the young animals imported minus the young animals exported.

---

[11] EUROSTAT. Meat production and foreign trade (annual data), 2008. http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database

For $k = Ya$

$$eAni\Pr od_{i,Fa} = (eAni\Pr od_{i,Ya} + \sum_{j,j\neq i} x_{j,i,Ya} - \sum_{j,j\neq i} x_{i,j,Ya}) YaToFa_{Fa,Ya} \geq 0, \quad (2.7)$$

where

$YaToFa_{Fa,Ya}$ = relation between young animal and fattened animal.

Additional equations 2.8a to 2.10b are added to the model in order to reflect real constraints that occur in real life. For instance, due to regional specialization (i.e. Parma ham from Italy) there are additional pull factors for transport of animals or meat. This is implemented in the model by introducing specific upper and lower bounds for certain flows of meat. These bounds are defined in the EUROSTAT Foreign trade (Comext) database[12].

For $i \in c_1$ and $j \in c_2$, for each pair of countries c_1, c_2 in NUTS 0

$$ComextData_{c_1,c_2,Ma} LowerLimit_{Ma} \leq \sum_i \sum_j x_{i,j,Ma} \quad (2.8a)$$

$$\sum_i \sum_j x_{i,j,Ma} \leq ComextData_{c_1,c_2,Ma} UpperLimit_{Ma} \quad (2.8b)$$

where

$ComextData_{c_1,c_2,Ma}$ = measured trade in meat from a given country to the rest of the world (EUROSTAT)

$LowerLimit_{Ma}$ = factor lowering $ComextData_{c_1,c_2,Ma}$

$UpperLimit_{Ma}$ = factor increasing $ComextData_{c_1,c_2,Ma}$

The flows of meat among countries, should be between the bounds of trade mentioned in the Comext database. The bounds are obtained by multiplying the data available in the Comext database (here denoted as ComextExportROTW) by a given factor based on expert advise.

$$ComextExportROTW_{c_1,Ma} LowerLimitExp_{Ma} \leq \sum_i z_{i,Ma} \quad (2.9a)$$

$$\sum_i z_{i,Ma} \leq ComextExportROTW_{c_1,Ma} UpperLimitExp_{Ma} \quad (2.9b)$$

where

$ComextExportROTW_{c_1,Ma}$ = measured trade in meat from a given country to the rest of the world (EUROSTAT)

$LowerLimitExp_{Ma}$ = factor lowering Comext export data

$UpperLimitExp_{Ma}$ = factor increasing Comext export data

---

[12] http://epp.eurostat.ec.europa.eu/portal/page/portal/external_trade/data/database

The flow of import of meat form the rest of the world, should be between the bounds of trade mentioned in the Comext database. The bounds are obtained by multiplying the Comext data (ComextExportROTW) by a given factor.

$$ComextimportROTW_{c_1,Ma} LowerLimitimp_{Ma} \leq \sum_i y_{i,Ma} \quad (2.10a)$$

$$\sum_i y_{i,Ma} \leq ComextimportROTW_{c_1,Ma} UpperLimitimp_{Ma} \quad (2.10b)$$

where

$ComextimportROTW_{c_1,Ma}$	= measured trade in meat from the rest of the world to a given country (EUROSTAT)
$LowerLimitimp_{Ma}$	= factor lowering Comext import data
$UpperLimitimp_{Ma}$	= factor increasing Comext import data

Furthermore, with respect to specific flows, transports of live animals should be consistent with the data registered in TRACES[13] for 2006/2007. For most animals this restriction is not binding, while other flows should be consistent with the past flows. For instance, this occurs for the transport of young heifers and bulls from France to Italy and Spain that are enforced to remain within 80 and 120% of the measured flows in 2006/2007. Finally, in our model we assumed the number of transported fattened calves for slaughtering between countries to be 0. The production of veal is regionally strongly specialized and it is estimated outside the model to gain better insight in the production, transportation and slaughtering of beef cattle.

The proposed model can be solved by means of any available LP solver. In the following sections, we will employ the proposed model in other to assess the impact of a set of possible policy revisions.

3. Potential policy revisions

In this section we discuss two potential policy revisions that have been proposed by NGOs: the first revision concerns travelling time for animals that are transported to a slaughterhouse; the second, proposes a revision of the space allowance for various species.

Travelling time

Council Regulation (EC) No 1/2005 defines, in chapter V, the journey times for different kinds of animals. This is summarized in Table 1 for international road transports exceeding nine hours. NGOs' proposal makes a distinction between animals that are transported to a slaughterhouse and other animals. The former can be transported for 8 hours, but this cannot be repeated (Stevenson, 2008). All other animals can be transported according to the constraints in table 1. The changes proposed are integrated in the mathematical model by excluding certain transport routes between NUTS 1 regions for animals transported to a slaughterhouse. If the distance between centers of two regions is more than 600 km (8 hr * 75 km per hr) the transport is not allowed. For all other animals the travelling times remains unchanged (see table 1).

[13] DG Sanco, TRACES Database. http://sanco.ec.europa.eu/traces/

Table 1: Travelling time[1], resting time[2] and conditions for transports of live animals per category of animals (source: (EC) No 1/2005))

Animal category	Travel time	Rest period	Second travel time	Additional conditions
Unweaned calves, Lambs & Unweaned piglets	9 hr	1 hr	9 hr	To be given liquid and if necessary fed during rest period
Pigs	24 hr			Access to water during journey
Domestic equidae	24 hr			Every eight hours to be given liquid and, if necessary, fed during journey
Poultry	12 hr			
Chicks of all species	24 hr			If completed within 24 hrs after hatching
All other animals	14 hr	1 hr	14 hr	To be given liquid and, if necessary, fed during rest period

[1] Travelling time start with the loading of the first animal onto the truck and ends when the last animal is offloaded.
[2] Resting time means resting at the truck, without offloading the animals.

Space allowance

In chapter VII of Council Regulation (EC) No 1/2005 the space allowances for animals are defined for transport by rail, transport by road, transport by air and transport by sea. In Table 2 the space allowances (expressed in m^2 per animal) are given for transport by road for the main categories of animals transported, in addition we also report the corresponding number of animals per truck. Space allowances are incorporated in the model by employing the information in Table 2.

A potential policy revision according to NGOs proposal consists in increasing the minimum space allowance per animal. Because they did not made a proposal we arbitrarily analyzed the impact of a policy revision according to which the number of animals per truck is reduced by 10% and 25 %.

Table 2: Space allowance for the most important animal categories traded internationally by road transport in the existing regulation (Council Regulation (EC) No 1/2005) and corresponding number of animals per truck.

Species	Type of animal	Weight (in kg)	Space allowance[1]	Animals per truck
Cattle	Calves	50	0.4	400
	Medium sized	325	1.30	60
	Heavy	550	1.6	24
Sheep	Lamb	20	0.3	750
	Heavy	60	0.3	500
Pigs	Piglet	25	0.134	960
	Slaughter pig	120	0.51	200
Poultry	One day old		25	50,000
	Broiler	1.6-3	160	10,000
Cattle	Calves	50	0.4	400
	Medium sized	325	1.30	60

[1] in m^2 per animal except for poultry (in cm^2 per chicken).

Scenarios

In this research three scenarios are compared. Firstly, for the years 2002 and 2013 the existing EU regulation No. 1/2005 is taken as a base scenario. The amount of animal and meat transported is therefore derived from the model without any change in the existing regulations. Secondly, the figures obtained for the year 2013 under this scenario are compared with those obtained under the proposals of the NGOs for limiting the travelling time for animals delivered to a slaughterhouse to eight hours and arbitrarily modifying the space allowance for difference species in such a way as to reduce the number of animal transported on a truck by 10% and 25%. In the following section we present the results of our assessment.

4. Impact assessment

Firstly, we consider for the year 2002 the existing EU regulation No. 1/2005. Production and consumption data at NUTS 1 level, as discussed, are obtained from the CAPRI model. The space allowance per animal in the council regulation (EC) No. 1/2005 is translated in the number of animals that can be transported on a truck; according to our previous discussion this directly affects the transport cost matrix entries. Table 3 shows the number of animals transported and the number of deliveries in 2002.

Table 3: Number of animals transported (in 1000 heads), number of deliveries and percentage of LDT in 2002 and 2013

	2002				2013			
	Total animals	Total deliveries	Animals % LDT	Deliveries %LDT	Total Animals	Total deliveries	Animals % LDT	Deliveries % LDT
Calves	1,214	3,036	33%	33%	974	2,435	34%	34%
Cattle	2,998	73,516	29%	23%	3,387	93,285	32%	31%
Pigs	21,372	64,041	32%	24%	31,745	108,755	53%	58%
Poultry	985,019	83,398	26%	18%	835,764	72,706	37%	29%
Sheep & goat	4,977	8,191	39%	38%	16,140	23,120	79%	76%
Total	1,015,580	232,181	26%	22%	888,010	300,300	38%	44%

In this table we report only the animals transported internationally, that is at NUTS 0 levels. The detailed figures for deliveries between NUTS 1 regions within the same country are not included for simplicity. A distinction is made between journeys lasting less than eight hours (short distance transport; SDT) and journeys lasting more than eight hours (long distance transport; LDT). In total one billion animals are transported in about 232,000 deliveries. 97 % of the animals transported are poultry, of which 74% is transported over short distances in 2002, 2.1% are pigs, 0.4% are cattle and 0.4% are sheep & goats. Cattle are transported in 33% of the deliveries, poultry in 36%, pigs in 28%, and sheep & goats only in 3% of the deliveries.

In Table 3 also the results are presented for 2013. The differences between 2002 and 2013 are caused by autonomic changes of production and consumption in the EU according to the CAPRI model. For the year 2013 CAPRI estimates a decrease in beef production and an increase in beef consumption. The net impact is that EU-27 becomes a net importer of beef. For poultry, consumption is estimated to increase faster than production. As a result, while the EU-27 was a net exporter of poultry meat in 2002, in 2013 it is able to produce just the right amount of poultry meat required to cover the projected consumption. For pig meat, the production stays at the same level. However consumption is estimated to decrease by 10%. The net effect is that the export of pig meat to the rest of the world increases by more than 100%. For sheep & goats, consumption and production decrease. Nevertheless, according to the forecast, the EU-27 remains a net importer in 2013.

According to the results produced by our model for these forecasts, the number of animals transported internationally is decreasing in 2013. This holds for calves (-20%) and poultry (-15%). The number of transported cattle, pigs and sheep & goats increases with, respectively, 13%, 49% and 224%. Table 3 also shows that for all species the percentage of LDT strongly increases. More specifically, the total number of LTD increases from about 52,000 in 2002 to 131,000 in 2013. Also the transport of meat intra EU increases by 45% between 2002 and

2013. By assuming that 20 tons of meat is transported in each delivery, the deliveries involving meat are about 633,000 in 2002 and about 922,000 in 2013. Import/export of meat to/from Europe to the rest of the world almost doubles between 2002 and 2013. The total distance travelled increases by 45% from 540 million km to 783 million km. We now aim to compare these projected results for 2013 with those obtained when modified policy restrictions are enforced.

Travelling time

In Table 4 we present the results for the scenario in which livestock delivered to slaughterhouses have a maximum travelling time of eight hours. The following changes are observed. The number of LDT deliveries and the animals transported on LDT will be halved; the main exception concerns sheep & goats, almost no impact for these categories of animals can be observed. The number of deliveries and the number of animals transported on SDT will increase by 29% when the travelling time is limited to eight hours in 2013 compared to the baseline scenario. The total number of animals transported changes only slightly (-2.6%) and the total number of deliveries decreases by 14% in 2013. From species to species the impact of the introduction of a travelling time limit varies. The total number of calves that are transported changes only slightly, but there is a 36% increase of the number of calves that are transported on LDT. For cattle, the number of animals travelling on LDT decreases by 29%. The total number of cattle transported increases by 4%. For pigs, the number of animals travelling on LDT (piglets) decreases by 61%. For poultry, the number of animals transported on LDT will be more than halved. Overall, about the same number of animals are transported between countries. For sheep & goats the impact is relatively limited, neither the long nor the short distance transports are affected by the travel time limit. The total distance travelled decreases by 3% from 783 million km to 755 million km.

Table 4: Number of animals transported (in 1000 heads), number of deliveries and percentage of LDT in 2013 under a maximum travelling time of eight hours for livestock delivered to slaughterhouses

	Total animals	**Total deliveries**	**Animals % LDT**	**Deliveries % LDT**
Calves	974	2,435	46%	46%
Cattle	3,581	101,334	22%	13%
Pigs	22,092	60,728	29%	11%
Poultry	822,964	71,426	17%	4%
Sheep & goat	15,611	22,062	82%	78%
Total	865,220	257,985	18%	16%

Space allowance +10%

Changing the space allowance by 10% per animal according to the policy revision previously discussed has the following overall impacts for the year 2013 compared to the baseline scenario. The total number of LDT deliveries will slightly decrease (-9%). The total number of animals transported is almost not influenced, the total number of deliveries increases by 3%. The impact per species strongly differs. For calves and sheep & goats almost no impact is expected. For poultry, we observe a small increase of the animals transported (1%) and an increase of SDT deliveries (6%), while LDT deliveries decrease by 10%. For pigs, the number of animals transported decreases (-14%) and we expect a decrease in LDT and SDT deliveries (-9% and -20%). For cattle, the number of animals transported does not change, but an increase in both LDT and SDT is expected (11%). The total distance travelled increases by 2% from 783 million km to 801 million km.

Space allowance +25%

Changing the space allowance by 25% per animal according to the policy revision previously discussed has the following overall impacts for the year 2013 compared to the baseline scenario. The total number of LDT deliveries will slightly decrease (-12%). The total number of animals transported is almost not influenced (-1%), the total number of deliveries increases by 10%. The impact per species strongly differs. For calves and sheep & goats almost no impact is expected. For poultry, we observe a small increase of the animals transported on short distance (7%) and a decrease of the animal transported on long distance (-12%). The number of consignments increases with 33%. For pigs, the number of animals transported decreases with 32% and we expect a decrease in LDT (-54%) and a small increase in SDT of 4%. For cattle, the number of animals transported does not change, but an increase in both LDT and SDT is expected (33%). The total distance travelled increases by 2% from 783 million km to 824 million km.

Combined policy (more space per animal and 8 hr traveling limit)

We now briefly discuss the impact of applying both the modified policy options concerning travelling time and space allowance. Combining in a regulation travelling time limits for animals delivered to slaughterhouses with additional space allowance leads to a reduction of LDT for all the species except for calves, for which LDT increases. Impacts are significant for pigs and poultry, moderate for cattle and calves, and almost absent for sheep & goats. Generally, these impacts are comparable to the first modified policy discussed that simply limits travel times. Nevertheless, the total distance travelled only decreases by 2% from 783 million km to 768 million km if the additional space is +10% and increases to 800 million (+2%) is the additional space is increased with 25%. Only for pigs the combination of time limit and additional space strongly affects the number of animals transported (respectively -14 and -32% for +10% space and +25% space), the number of consignments (-11% and -30%) and especially the number of LDT (-2% and-54%). For the other species only the number of consignments increases because less animals can be transported on one truck.

In Table 5 we present an overview of the results discussed so far. Imposing an eight hours travelling time limit for animals delivered to a slaughterhouse heavily impacts all the species in different ways, except for sheep & goats. LDT for cattle, pigs and poultry is significantly reduced (see table 6). In contrast, such a travelling time limit increases the number of calves transported on LDT. This is easily explained by the fact that a travelling limit on adult animals that are delivered to slaughterhouses produces, as a side effect, an increase of LDT for young animals, on which the limits in the existing regulations apply. An increased space allowance that reduces by 10% the number of animals on a truck with respect to the original regulation does not have an impact on LDT for calves, cattle and sheep & goats. On the other hand, it moderately reduces the number of animals on LDT for pigs and poultry. In terms of LDT reduction, a combined policy is generally comparable to a policy that only imposes an eight hours travelling time limit for animals delivered to a slaughterhouse. Only LDT for poultry is further reduced in the combined policy.

Table 5: Number of animals per species transported on LDT in 2013 for the different policy options considered

	Number of animals (in 1000)					
	Existing regulations	Reduced travelling time	Increased space allowance (+10%)	Increased space allowance (+25%)	Combination (+10% & 8hr limit)	Combination (+25% & 8hr limit)
Calves	331	450	331	331	450	425
Cattle	1,093	771	1,093	1,095	771	771
Pigs	16,742	6,477	15,295	8,484	6,488	6,477
Poultry	307,910	135,878	278,489	270,566	135,878	135,878
Sheep & goat	12,735	12,867	12,735	12,755	12,867	12,867

Table 6: Percentage of animals per species transported on LDT in 2013 for the different policy options considered

	% of animals (existing policy=100%)				
	Reduced travelling time	Increased space allowance (+10%)	Increased space allowance (+25%)	Combination (+10% & 8hr limit)	Combination (+25% & 8hr limit)
Calves	136%	100%	100%	136%	128%
Cattle	71%	100%	100%	71%	71%
Pigs	39%	91%	51%	39%	39%
Poultry	44%	90%	88%	44%	44%
Sheep & goat	101%	100%	100%	101%	101%

5. Sensitivity analysis

In order to give some insights on the sensitivity of the model to input parameters variations, two aspects are considered: an increase of the fuel price for trucks by 50%, from 0.80 euro per liter to 1.20 euro per liter; and a decrease in the transport cost of meat, which is simulated by assuming a 50% load for return freight transporting meat. We recall that the original assumption was that return freights were empty.

Firstly, our computational experience shows that a 50% increase of the fuel price did not influence the results. The number of animals transported, the number of deliveries, the transport of meat and the distance travelled all changed less than 1%. This result can be expected because both the costs of the transport of live animals and the costs of the transport of meat increase.

Secondly, if the return freight load for meat transport is increased from zero to 50% the transport of meat increases from 592 million km to 674 million km and the transport of live animals decreases from 191 million km to 133 million km. Especially the transport of fattened pigs and broilers is affected, it decreases from respectively 75 and 36 million km to 30 and 22 million km, while the transport of pig and poultry meat increases. The impact on cattle and sheep & goats is negligible. The model is therefore particularly affected by assumptions made on the cost of meat transport.

6. Discussion and Directions for Future Research

TRAM represents a first step in the modeling of the transport of livestock and meat in the EU. Nevertheless, the model still presents a number of limitations that also represent opportunities for future research. In this research project only the impact on the number of transported animals per species and on the number of deliveries is estimated. The impacts on animal welfare, animal health, social aspects and profitability have not been considered and may be included in future extensions. More specifically, our research is limited to the economic aspects of the transport of live animals. The research was limited to cattle, sheep & goats, pigs and poultry. Other animal species may be included in the future as soon as data become available. The supply chain covered by the transport model starts with young animals and ends with transport of meat to consumers. With respect to meat, no distinction is made between carcasses, hams or end products. The model built is limited to the EU-27. All other countries are treated as one region, called the rest of the world. This assumption may be relaxed and the model can be in principle easily extended to consider other regions in the world. All calculations are made on an annual basis. Temporary shortages or surpluses within a year are ignored. Future works may explore the possibility of extending the model in such a way as to consider multiple, shorter planning periods.

7. Conclusions

We presented a model, TRAM, which can be used in order to assess the impact of different policy restrictions on the transport of livestock and meat in the EU. This model has been employed in order to assess the impact of a number of policy restrictions that were proposed by NGOs. Namely, a restriction in the maximum travelling time for animals shipped to slaughterhouses and an increase in the space allowance for animals being transported. But also other policy restrictions concerning traveling limitations and space allowances can be assessed in TRAM.

Our results suggest that the proposed changes in the regulation concerning travelling times and space allowances for transports of live animals are effective, in the sense that LDT will be strongly reduced. Our model also predicts an increase of SDT and LDT in the international transport of livestock for 2013 with respect to the situation in 2002. Limitation of LDT for animals shipped to slaughterhouses impacts the transports of pigs, cattle and poultry. The number of animals transported on LDT is not significantly affected for sheep & goats. The total number of animals transported and the total number of international deliveries is only slightly reduced, because SDT increases. Increasing the space allowance for animals also decreases LDT and increases SDT, but in a less significant way. The total number of deliveries, under an increased space allowance, increases by 3%, partly because more deliveries are needed to transport the same amount of animals and partly because more animals are transported. The combination of limitation of travelling times and increasing space allowances has the most significant impact, although such an impact does not differ much from that of a policy that simply limits travelling time for animals delivered to a slaughterhouse. Finally, on a per species basis, the impact of the proposed policy revisions differs significantly. For sheep & goats, the impact on the number of animals and number of long distance deliveries is almost absent. The number of animals transported on LDT decreases significantly for pigs and poultry. Cattle show a moderate decrease in the number of animals on LDT.

References

European Union, 2003. REGULATION (EC) No 1059/2003 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 May 2003, “on the establishment of a common classification of territorial units for statistics (NUTS)”. Official Journal of the European Union

European Union, 2005. REGULATION (EC) No. 1/2005 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL “on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No. 1255/97”. Official Journal of the European Union

Garcés L., V. Cussen and H. Wirth, 2008. Viewpoint of Animal Welfare Organizations on the Lond Distance Transportation of Farm Animals. Veterinaria Italiana, 44 (1):59-69

Gijsberts W., and E. Lambooij, 2005. Oxen for the axe. A contemporary view on historical long-distance live stock transport. In: By, marsk og geest 17. Kulturhistorisk aarbog for Ribe-egnen. Publisher Ribe Byhistoriske Arkiv & Den antikvariske Samling I Ribe Forlaget Liljeberget

Gribrovskaia, B. O., Gullberg, K. J. Hovden, and S. W. Wallace, 2006. Optimization Model for a Livestock Collection Problem. International Journal of Physical Distribution & Logistics Management, 36 (2):136-152

Horne, P.L.M., van, 2009. Productiekosten van kuikenvlees; Een internationale vergelijking. LEI, Wageningen UR, the Netherlands

Hoste, R., C. van Wagenberg, R. Bergevoet and L de Schutter, 2007. Investeren in de varkenskolom in Hongarije, Roemenië, Oekraïne en Rusland. LEI, Wageningen UR, the Netherlands

Lambooij E. and B. Engel, 1991. Transport of slaughter pigs by truck over a long-distance – some aspects of loading density and ventilation. Livest Prod Sci, 28:163-174

Ljungberg, D., G. Gebresenbet and S. Aradom, 2007. Logistics Chain of Animal Transport and Abattoir Operations. Biosystems Engineering, 96 (2):267-277

Malena, M., E. Voslarova, A. Kozak, P. Belobradek, I. Bedanova, L. Steinhauser and V. Vecerek, 2007. Comparison of mortality rates in different categories of pigs and cattle during transport for slaughter. Acta VET. BRNO, 76:S109-S116

Perremans S., and R. Geers, 1996. Effect of transport on some welfare characteristics of slaughter pigs. Vlaams Diergenskund Tijds, 65:310-317

Stevenson, P., 2008. Long distance animal transport in Europe: a cruel & unnecessary trade. Compassion in World Farming

Vanhonacker F., W. Verbeke, E. Van Poucke and F.A.M. Tuytens, 2008. Do citizens and farmers interpret the concept of farm animal welfare differently?. Livestock Science, 116:126-136

Vermeij, I., B. Bosma, A. Evers, H. Hemmer, I. Vink, 2007. Kwantitatieve Informatie voor de Veehouderij (KWIN) Veehouderij 2007-2008. Animal Sciences Group, Wageningen UR

Warriss, P. D.,1998. The welfare of slaughter pigs during transport. Anim Welf, 7:365-381

World Organisation for Animal Health, 2009. Terrestrial Animal Health Code 2009. www.oie.int/eng/normes/Mcode/en_sommaire.htm