An assessment of the economic and legal consequences of a EU prohibition on livestock cloning

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Preface

This article is the closing-piece of my education at the Catholic University of Leuven to become a Master in European Studies. It concludes a period which most people describe as the most beautiful time in their life. It was a period of freedom to discover and a period of personal development. Every ending, however, also equals a new beginning and hopefully this one is the start of a successful and sumptuous career.

This preface is an acknowledgement to all the people who contributed to what these recent years have become. In the first place, my mother for all the opportunities she presented to me, the unconditional support and the deep-rooted conviction in my capacities. I also thank the rest of my family, my friends, my fellow students and the professors and staff of the Lipsius Centre for European Studies for all the pleasant moments we shared together in Leuven, Rome and Strasbourg.

A special word of thank goes out to my supervisors, Prof Dr Geert van Calster and Prof Dr Aad van Mourik, not only for all their suggestions and detailed corrections of the texts, but also for their enthusiasm about the topic and continuous support while writing this thesis. I also want to express my gratitude to Prof Dr Calum Turvey of Cornell University, who helped me with adapting his economic approach towards the precautionary principle to the situation described in my thesis. Finally, I thank Liam Aylward, Johannes Blokland, Frieda Brepoels, and Caroline Lucas of the Committee on Environment, Public Health and Food Safety of the European Parliament for providing me with their opinion about livestock cloning.

Walter Reynders

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Abstract

It is expected that products derived from the offspring of cloned animals will enter the global food chain before 2010. This article shows that, for the time being, the European Union will probably refuse to partake in this development for reasons of food safety and moral concerns. A EU prohibition on livestock cloning would only require some minor modifications to the existing legislative framework and would be compatible with WTO obligations. The economic analysis in this article shows that the overall effect of such a prohibition on European welfare depends on the size of the differences Europeans perceive in quality between cloned products and their traditional counterparts, the variable production costs and prices of both products and on the possible labelling cost for cloned products.

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1. Introduction

Animal cloning is becoming more and more mundane. Scientists have already successfully cloned cats, cows, deer, goats, horses, mice, mules, pigs, sheep and rabbits. It is expected that animal cloning will soon play an important role in agriculture, pharmaceutics, recreation of extinct species and sports like hunting and horse racing. In the works are projects to clone goats with less fatty milk, chickens without feathers and environment friendly pigs whose manure has less phosphorus.[1] It will not take long before these animals enter the food chain.

After all, on 28 December 2006, the United States Food and Drug Administration (FDA) issued a draft risk-based approach to evaluate the food safety of animal clones and their progeny. This risk assessment concludes that "*edible products from healthy clones […] pose no increased food consumption risk(s) relative to comparable products from sexually-derived animals [and] edible products derived from the progeny of clones pose no additional food consumption risk(s) relative to corresponding products from other animals.*"[2]

Therefore, it is expected that the US, but also Japan, China, South Korea and Australia will allow animal cloning for agricultural purposes in the near future.[3] The cloning industry anticipates that "*products derived from the offspring of cloned cattle and pigs are likely to enter the food chain somewhere in the world before 2010.*"[4] The prospects are that food products derived from cloned animals themselves will enter the global food chain before 2015.

This article explains why the European Union may refuse to partake in these developments and examines the economic and legal consequences of a EU prohibition on livestock cloning. The following section presents an overview of the methodology used to conduct this research. Section three describes the main findings of this study.

[1] Fiester (2005:330)
[2] United States. FDA. (2006:15)
[3] CeBRA (2006a:7)
[4] Suk, J, et all. (2007:48)

Section four takes a broad look at these findings, explains the implications of the study and makes recommendations for future research.

2. Methodology

A vast majority of experts anticipates that the European Union will reject dairy and meat products from cloned animals because of ethical and food safety concerns. The European Commission, however, has not yet made any official statements about its position on livestock cloning, nor did it pass any binding legislation about the issue. In order to verify the precise position of the European Union on livestock cloning and the reasons why Europe may refuse to partake in livestock cloning, the European Commission DG SANCO and the 68 members of the European Parliament Committee on Environment, Public Health and Food Safety were contacted by email or telephone. Unfortunately, DG SANCO never responded and only a limited number of European parliamentarians expressed their opinion about livestock cloning.

Therefore, it was necessary to dig into the primary sources on which the European Commission may base its opinion and cloning legislation in order to determine the EU stance on farm animal cloning. The first of these sources is Opinion N°9 of the Group of Advisers on the Ethical Implications of Biotechnology to the European Commission (GAEIB) on the Ethical Aspects of Cloning Techniques. The other documents originate from the CLONING IN PUBLIC project under the Sixth Framework Programme of the European Commission. This project is coordinated by the Danish Centre for Bioethics and Risk Assessment (CeBRA) with the objective to make recommendations on regulation and on guidelines for research and applications of farm animal cloning.

The twelve CLONING IN PUBLIC reports solely focus on the ethical and societal consequences of farm animal cloning across the EU. Food safety concerns may, however, also influence EU decision making as the Center for Food Safety, a Washington, DC-based lobby group, claims that the FDA's risk assessment "*is based on unsubstantiated assumptions, misreported findings, and flawed analyses of scientific research.*"[5] Therefore, the first result section also includes a discussion of the most

[5] Center for Food Safety. (2007:1)

recent secondary sources related to the food safety of livestock cloning which are published in quality journals such as Cloning and Stem Cells, Molecular Reproduction and Development, Nature Biotechnology and Theriogenology.

When the EU refuses products derived from cloned animals to enter the food chain, it is likely that trade disputes with countries who wish to export to the European market arise. Therefore, the second result section reviews the conformity of an EU prohibition on livestock cloning with WTO obligations. This section is written in close cooperation with Geert Van Calster, associate professor at the Catholic University of Leuven and an expert in international trade law. The law review is based on the relevant previsions of the SPS Agreement and the General Agreement on Tariffs and Trade (GATT), WTO Panel and Appellate Body reports and insight obtained during the course "The Law of the World Trade Organization" at Leuven University, fall 2006.

A European prohibition on livestock cloning will not only have legal consequences. A 1998 study by Bureau, Marette and Schiavina of the Institut National de la Recherche Agronomique (INRA) shows that the welfare effect of trade liberalisation in credence goods is ambiguous. Credence goods are "*goods whose quality cannot be determined by consumers either before or after consumption.*"[6] Since cloned meat qualifies as a credence good, INRA's study will be used as a starting point to analyse the welfare effects of trade liberalisation on the EU market in the case of cloned meat.

INRA's model serves as a good instrument to incorporate ethical concerns in a welfare analysis, but cannot be used to address the food safety concerns regarding cloned products. A solution can be found in a 2005 study by Calum Turvey and Eliza Mojduszka. These two American economists investigated the unintended consequences of applying the precautionary principle in the 2002 famine in Southern Africa where the African countries rejected US assistance in the form of GMO products because of health and environmental risks and the possible trade consequences with the EU. The model will need some modifications because it considers the precautionary principle as a necessary evil while the EU stance towards this principle is more positive. It serves

[6] Bureau, Jean-Christophe, Stephan Marette, and Alessandra Schiavina (1998:4)

nevertheless as a fine instrument to examine the implications of a precautionary EU approach towards cloned products on European welfare.

3. Results

3.1 Concerns about farm animal cloning

The FDA statement about animal cloning has resulted in a lot of criticism. The most persuasive argument is that animals involved in the cloning process endure a lot of suffering such as high rates of miscarriage, stillbirth, early death, genetic abnormalities and chronic diseases. These abnormalities and diseases could pose food safety risks and correspondently endanger human health. The most recent findings related to the cloning of cows, pigs and goats are discussed below.[7]

A large study, covering five years of field experience, demonstrates just 317 live calve births out of 3374 cloned embryos, while 42 percent of the cloned calves died within 150 days because of hydrops, an abnormality that usually results in euthanasia.[8] The estimated frequency of hydrops in natural breeding or other assisted technologies is 3150 times lower. The most common abnormalities found in the live-born calves were enlarged umbilical cords (37%), contracted flexor tendons (21%) and respiratory problems (19%).

One of the most recent experiments on pig cloning reveals that, out of 40 somatic cell cloned (SNCT) piglets, five died at birth and 22 did not survive their first week of life because of many health problems, including cerebromeningitis, hemodynamic disorder, diarrhoea and leg and face abnormalities. "*25% (7/28) of [cloned pigs] showed severe congestion of lung and liver or neutrophilic inflammation in brain indicating that unexpected phenotypes can appear as a result of somatic cell cloning*."[9]

[7] Sheep are ignored because the FDA already acknowledged that cloned sheep would be unsuitable for consumption.
[8] Panarace, M, et al. (2007:149)
[9] Park, Mi-Rung, et all. (2005:1928)

Goats are usually not seen as a source of meat but they produce dairy products, especially cheese. A 2005 study reports signs of the large offspring syndrome: "*anomalies at birth included enlarged umbilical stumps (one dead and two live fetuses) and minor tendon laxity in the limbs (three of four live animals); and minor generalized edema.*"[10] Another study found that the offspring of cloned goat show significantly shorter telomere length than their non-cloned counterparts.[11] Shorter telomeres are an indication of a shorter lifespan. The FDA argues that the harmful effects for cloned animals are constantly declining because the technology is improving.[12] FDA data, however, demonstrate the contrary: "*survival rates of clones in the most recent studies are actually lower than the rate in earlier studies."*[13] Moreover, *"[t]he success rates remain low (less than 5%) regardless of methodology."*[14]

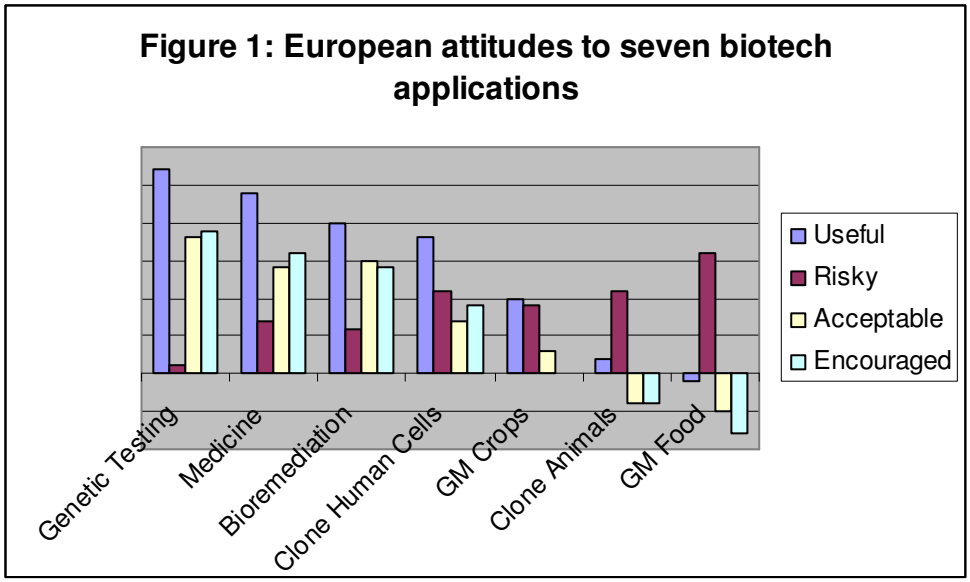
In addition, the FDA claims that genetic abnormalities will not create food safety problems because affected animals will be removed from the food chain. "*But scientists have found that defects in clones can be hidden and undetectable, and could pose food safety risks. FDA also admits that even young clones that fall sick or die early could in some circumstances be sent into the food supply, and that some health problems found in clones are not conditions that typically exclude animals from food use."*[15] Therefore, also concerns about human health are justified.

The FDA also argues that only clone offspring will enter the food chain and that reproduction of progeny corrects the common defects found in clones. The cloning industry, however, expects cloned cattle and pigs themselves to enter the food chain somewhere in the world before 2015.[16] Moreover, a study has demonstrated that the offspring of cloned goat show significantly shorter telomere length than their non-cloned counterparts.[17] Reproduction thus does not always rectify genetic mistakes.

The 1999 Eurobarometer survey indicates that these concerns for public health are very well-alive within the European public. Noteworthy about this survey, is that it defines

[10] Behboodi, et.all (2005:107)
[11] Betts, et.all (2005:465)
[12] United States. FDA (2006)
[13] Center for Food Safety (2007:3)
[14] CeBRA (2005c:25)
[15] Center for Food Safety (2007:8)
[16] Suk, J, et all. (2007:48)
[17] Betts, et.all. (2005:465)

animal cloning as the use of cloned animals to create medicines and vaccines while GM food is defined as "*the use of modern biotechnology in the production of foods, for example, to make them higher in protein, keep longer, or change the taste.*"[18] Animal cloning for agricultural purposes thus better suits the GM food category than the animal cloning category.



Sources: European Commission. INRA (Europe) - ECOSA. The Europeans and Biotechnology. Brussels: GPO, 2000 and Gaskell, et al. "Biotechnology and the European public." Nature Biotechnology 18(2000): 935-938.

Figure 1 demonstrates that Europeans distinguish GM food as the most risky, morally unacceptable and useless of all seven biotech applications and strongly believe it should not be encouraged. The differing results for GM crops and GM food suggest that Europeans are more worried about the impact on food safety than on the environment. A similar survey in the US showed that Americans perceive GM food as being more useful for society, less risky and more morally acceptable than Europeans do.[19]

Even with agricultural purposes excluded, Europeans believe that animal cloning is morally unacceptable and that it should not be encouraged (see Figure 1). The Eurobarometer data set shows that 61 percent of the European public dreads the idea of cloning animals and 77 percent believes cloning animals is fundamentally unnatural

[18] Gaskell, et all (2000:936)
[19] European Commission. DG Research (2006:82)

even if it has benefits.[20] These figures demonstrate why EU regulation should go beyond scientific risk assessment and also take the ethical and moral dimensions into account.

The European Commission is well-aware of these concerns and requested an update of a 1997 opinion by the Group of Advisers on the Ethical Implication of Biotechnology to the European Commission (GAEIB). GAEIB stated that the cloning of farm animals is acceptable when it is carried out under the following ethical conditions:

- *"the duty to avoid or minimize animal suffering since unjustified or disproportionate suffering is unacceptable;*
- *the duty of reducing, replacing and when possible refining the experimentation adopted for the use of animals in research;*
- *the lack of better alternatives;*
- *human responsibility for animals, nature and the environment, including biodiversity.*"[21]

The GAEIB also declared that the European institutions should pay specific attention to sustain the genetic variety in farm animals. The public should be protected against possible health risks and provided with adequate information. Moreover, consumers should gain from the possible reduction in production costs.[22] An updated opinion will be provided in 2007 by GAEIB's successor, the European Group on Ethics in Science and New Technologies to the European Commission (EGE).

The EGE is likely to base its opinion on the conclusions of "Cloning in Public", a project carried out by the Danish Centre for Bioethics and Risk Assessment (CeBRA) under the Sixth Framework Programme of the European Commission. At the 14th EGE meeting on 10-12 April 2007 in Brussels, Dr Peter Sandoe (Director of CeBRA) expressed his concerns about animal welfare, animal integrity, bio safety and the industrialisation of agriculture. Moreover, he stated that "*it may be argued that cloning*

[20] CeBRA (2005b:14)
[21] GAEIB (1997:Art. 2.3)
[22] GAEIB (1997, Art. 2.4 & 2.5)

of animals is only acceptable if substantial needs are at stake [and] it may therefore be argued that animal cloning for food supply is not acceptable."[23]

Also present at this meeting was Dr Herman Köter, Director of Science of the European Food Safety Authority (EFSA). The European Commission has asked EFSA "*to advice on food safety, animal health, animal welfare and environment implication of live cloned animals, obtained through somatic cell nucleus transfer (SCNT) technique, their offspring and of the products obtained from those animals.*[24] EFSA hopes to finish a draft opinion which will be accessible to the public by November 2007 and to issue its final opinion in the first months of 2008.[25]

In sum, some scientific reports do not rule out that the cloning of farm animals could pose risks for public health. Moreover, animal cloning raises concerns about animal welfare and 61 percent of the European public dreads the idea of cloning animals while 77 percent finds it fundamentally unnatural. Therefore, the European Commission requested EGE and EFSA for an opinion regarding the cloning of farm animals. The EGE is likely to conclude that the cloning of farm animals is morally unacceptable. The EFSA report will probably be less explicit than the FDA risk assessment since EFSA will also take animal health, animal welfare and environmental implications into account. Consequently, a EU prohibition on the cloning of farm animals seems imminent.

3.2 Legality of an EU ban on farm animal cloning

Currently, animal cloning in the EU is regulated by a body of binding EU legislation, in the form of regulations and directives. This indirect regulatory framework aims to ensure food safety in the EU, to inform consumers and to protect animal health and welfare. According to the CLONING IN PUBLIC project, "*some uncertainty and possible gaps remain in relation to farm animal cloning.*"[26] The project provides three

[23] Sandoe, Peter (2007)
[24] European Commission. DG SANCO (2007:3)
[25] EFSA (2007:1)
[26] CeBRA (2006a:16)

main regulatory options for the EU to eliminate these uncertainties and to fill the gaps in the current legislation.

One possibility is to regulate farm animal cloning through existing regulatory mechanisms at EU level with a few small adjustments. An alternative is to introduce new regulation at EU level specifically to cover farm animal cloning. Thirdly, it must be taken into account that individual member states may introduce their own national regulation independently, i.e. even if no specific regulation at EU level is introduced. At this moment, only one in twenty-seven member states has specific legislation on the cloning of animals. Denmark allows animal cloning but solely for research purposes.

No matter which regulatory option the EU takes, countries such as the US, Japan, South Korea and Australia would be delighted with the opportunity to export products derived from cloned animals to a market the size of the EU and are expected to file a complaint to the WTO when the EU forbids the imports and sales of these products.[27] This section will therefore review the consistency of an EU prohibition with WTO obligations. The first part focuses on public health risks and examines the conformity with the Agreement on the Application of Sanitary and Phytosanitary Measures, commonly referred to as the SPS Agreement. Part B concentrates on ethical concerns and reviews the consistency with the General Agreement on Tariffs and Trade (GATT). The last section provides an overall conclusion of the main findings regarding the legality of a EU prohibition on livestock cloning.

A. Consistency of the EC moratorium with SPS Agreement

The previous chapter demonstrated that cloned animals suffer from high rates of chronic diseases. The possibility exists that diseased animals enter the food chain, hereby affecting public health. The SPS Agreement explicitly recognises that "*members have the right to take SPS measures necessary for the protection of human, animal or plant life or health"* within their territory.[28] This right is however not unlimited. Members have to satisfy two requirements in order to impose SPS measures.

[27] Brepoels, Frieda. "Re: Vraag in verband met thesis." E-mail to author.22 Feb 2007 and Aylward, Liam. "Answers to questions on meat cloning." E-mail to author.1 Mar 2007.
[28] SPS Article 2.1

The first prerequisite for SPS measures is that they "*shall not be applied in a manner which would constitute a disguised restriction on international trade [and] do not arbitrarily or unjustifiably discriminate between Members where identical or similar conditions prevail.*"[29] This includes discrimination between the home country and third countries. Assuming all 27 EU member states refuse to partake in the farm animal cloning business, this requirement is believed to be fulfilled.

The second requirement obliges members to ensure that the measure is "*based on scientific principles and is not maintained without sufficient scientific evidence.*"[30] Currently, no available scientific evidence proves that the consumption of products derived from cloned animals is unsafe. However, "*in cases where relevant scientific evidence is insufficient, a Member may provisionally adopt SPS measures on the basis of available pertinent information.*"[31]

Subsequently, the first question is whether the scientific information provided by the FDA is insufficient. Based on the Appellate Body Report in *Japan-Apples*, SPS Article 5.7 addresses "*situations where there is a true lack of sufficient scientific evidence regarding the risk at issue, either due to the small amount of evidence on new risks, or due to the fact that accumulated evidence is inconclusive or unreliable.*"[32] The criticism on the FDA risk assessment indicates that it may be unreliable. Consequently, the first requirement for adapting the precautionary approach may be fulfilled.

Secondly, the precautionary principle should be based on available pertinent information. Maverick science would suffice as long as it meets with the peer review process.[33] A 2007 study demonstrates that the composition of meat and milk products from physiologically normal cows may be somewhat different, but the health risk of consuming such products would be very limited.[34] This study, nonetheless, qualifies as pertinent information that points to the danger of cloned food consumption.

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[29] SPS Article 2.3
[30] SPS Article 2.2
[31] SPS Article 5.7
[32] Van den Bossche, Peter, Denise Prévost, and Mariëlle Matthee. (2005:59)
[33] EC Hormones – Appellate Body Report
[34] Heyman, et.all (2007:140)

In sum, the EC can prohibit the imports and sales of products derived from cloned animals or their offspring for reasons of public health, based on the precautionary principle laid down in SPS Article 5.7. Consequently, the measure is consistent with the SPS Agreement. However, when EFSA's risk assessment would conclude that the consumption of cloned animals is as safe as their traditional counterparts, the EC would no longer be able to ban these products for public health reasons.

B. Consistency of the EC moratorium with GATT Article XX(a)

The protection of public health is not the only purpose of the EU prohibition. The European Union also has ethical concerns, such as animal welfare, animal integrity, biodiversity and the industrialisation of agriculture. These concerns are so entrenched in the EU that animal cloning for agricultural purposes is considered morally unacceptable[35]. GATT Article XX(a) allows countries to ban products for such reasons, provided the following requirements are fulfilled:

1) the issue falls within the scope of "public morality";
2) the measure is legitimately directed at that moral interest;
3) the measure is non-discriminatory;
4) the measure is not more trade restrictive than necessary.[36]

Public morals are "*standards of right and wrong conduct maintained by or on behalf of a community or nation."*[37] Accordingly, "*any law passed by a representative government prohibiting any behaviour could be considered a social judgement about right and wrong."*[38] Moreover, the history and preparatory work of GATT 1947 advocate that products linked to animal cruelty fall within the scope of Article XX(a).[39] Therefore, it would be surprising if a Panel or Appellate Body would reject that animal cloning falls within the scope of "public morality".

Secondly, a Panel has to examine if the measure is legitimately directed at that moral interest. The ban on animal cloning for farming purposes is obviously legitimately

[35] Sandoe, Peter. (2007).
[36] Marwell, Jeremy C (2006:814)
[37] Gambling Panel, 6.465.
[38] Marwell, Jeremy C (2006:816)
[39] Idem p819

directed at the protection of animal welfare, animal integrity, biodiversity and the industrialisation of agriculture. In a next step, the Panel has to certify that the measure is non-discriminatory. Since the regulation would apply to all countries including the EU member states, this condition is fulfilled.

Finally, the Panel has to ensure that the measure is not more trade restrictive than necessary. A trade measure is necessary when there is no reasonably less trade-restrictive alternative available which achieves the desired objective. The US may argue that allowing imports of clearly labelled cloned meat is such an alternative that would not infringe European public morals. The EU, on the other hand, may argue that such an alternative is not reasonably available since there is currently no method available to distinguish cloned meat products from their traditional counterparts.

C. Legal conclusion

This analysis has shown that, in light of the current scientific uncertainty about the safety of edible products obtained from cloned animals or their offspring, an EU ban on such products may be justified according to the precautionary principle laid down in SPS Article 5.7. If a Panel accepts that it is impossible to adequately distinguish meat products from cloned animals or their offspring from traditional meat products by means of a label, an EU moratorium may also be justified to protect public morals according to GATT Art. XX(a).

3.3 Economic analysis of a EU ban on cloned meat

Economic factors played a crucial role in the design of Dolly, the first mammal to be cloned from adult cells. The researchers who designed Dolly immediately filed two patent applications which cover use in all animals and in most countries of the world. Currently, "*artificial insemination allows each bull to have thousands of offspring but each cow can only produce five or six calves in a lifetime.*"[40] Nuclear transfer has the potential to partially rectify this disparity. Some estimate the economic benefit from livestock cloning to be *"$20 billion in value added annually to the $50 billion US cattle*

[40] Fransman, Martin (2001:269)

industry."[41] A European moratorium on cloned meat products will therefore certainly damage the US cattle industry.

The two models in this section demonstrate that the effects on European welfare however are ambiguous. In the first model, the assumption is made that there are some doubts about food safety, but consumer preference is ignored. The second model assumes that cloned meat is safe but European consumers still prefer clone-free meat due to moral concerns. The combination of both models should be able to estimate the effects a moratorium on cloned meat would have on European welfare.

Model 1: Food safety concerns

At this point in time, still some food safety concerns about cloned products exist. Consequently, the moment when the market gets liberalised is an important factor since scientific knowledge increases over time and the level of certainty whether meat, milk and eggs obtained from cloned animals could have unintended consequences or not, will become more precise. In other words, the probability of Type I and Type II errors will diminish over time.

A Type I error occurs when the null hypothesis is rejected while the statement is actually true. The European Union might reject the null hypothesis that the consumption of meat, milk and eggs from cloned animals is safe while it is essentially true. Accordingly, market benefits could have been realised and the Type I error entails a welfare loss for the European Union. A Type II error arises when the null hypothesis is accepted while it should have been rejected. Thus, if the European Union accepts that the consumption of meat, milk and eggs from cloned animals is safe, while it actually is not, a Type II error will occur.

When a Type II error arises, it is important to know whether or not the policy is reversible. Reversibility refers to the capacity of the government to undo a certain policy measure when it turns out that the social benefits of such an action are greater than the social costs. The answer in this case depends on the extent of market

[41] Gillespie, Ron (2002)

penetration by cloned animals but is in most cases probably yes. The cost of reversing the policy, however, increases with the amount of market penetration. Still, some costs are irreversible, such as environmental costs and people getting sick or dying from consumption of unsafe products derived from cloned animals.

Turvey and Mojduszka (2005) developed a framework of how policy makers should respond when scientific uncertainty exists. Their model assumes that "*experimental protocols and risk assessments have been met to scientific standards but that in the absence of scientific certainty there remains a probability P that the product can at some future date cause harm to humans, animals or the environmen*t."[42] When the European Union applies a policy, defined by θ, based on the precautionary principle to ban the commercialization of animal cloning, the policy should "*balance uncertainty about future hazards occurring at some unknown time, T, based on information available at time t.*"[43]

The optimum policy, according to Turvey and Mojduszka, is then achieved by maximizing the expected social welfare function:

$$E[W] = [P(\theta, t)W_1(\theta, T) + (1 - P(\theta, t))W_0(\theta, t)]\, e^{-\lambda T} - C_0(\theta) \qquad (1)$$

where $P(\theta, t)$ is the probability of hazard assigned to scientific uncertainty, $(1 - P(\theta, t))$ denotes the scientific certainty known at time $t < T$; $W_1(\theta, T)$ is the economic welfare that will arise if a future hazard at T occurs. $W_0(\theta, t)$ is the economic welfare that occurs in the embargoed state at the present time. Its value is thus known at the moment when the policy is put into practice and $W_0(\theta, t) > W_1(\theta, T)$ because hazard is expected to occur at T. $C_0(\theta)$ are the direct economic costs of implementing the trade-restrictive policy such as "*lost investment opportunities, lethargy in research and development, lost economies to the intended recipients of the scientific research, and any compensation to the industry as a result of the policy.*"[44]

The social discount rate, defined by λ, represents the willingness of people to wait for scientific certainty. This rate can differ across the population. For example, producers of meat, milk and eggs may want to engage in cloning techniques immediately because of

[42] Turvey, C.G., and E.M. Mojduszka(2005:152)
[43] Idem
[44] Idem p154

the expected economic payoffs while consumers might want to wait until it is absolutely certain that consumption of such products is safe. However because of lobbying activities, the farm sector sometimes becomes the policy maker while the consumers are the policy takers. In that case, λ will represent the willingness of farmers to wait for scientific certainty and the policy will have unintended consequences for society.

Turvey and Mojduszka obtain the optimal policy decision by taking the derivate of expected welfare with respect to the policy parameter, θ, and setting it equal to zero:

$$\frac{\partial W}{\partial \theta} = \left[\frac{\partial P}{\partial \theta} (W_1 - W_0) + \left(\frac{\partial W_1}{\partial \theta} + \frac{\partial W_0}{\partial \theta}(1 - P) \right) \right] e^{-\lambda T} - \frac{\partial C_0}{\partial \theta} = 0 \qquad (2)$$

The terms between the brackets correspond to the benefits of delaying the commercialisation of animal cloning. Keep in mind that $W_0 > W_1$ so that $W_1 - W_0$ is negative. However, $\frac{\partial P}{\partial \theta}$ is also negative, since the introduction of cloned products is postponed in the hope that scientific uncertainty will be reduced when market liberalisation is delayed. Consequently, the product of both factors is positive. In other words, the harm done in the eventuality of a problem falls if the policy is to wait and the probability of harm also decreases. This decrease can be interpreted as a benefit to the policy. The second term in equation (2) entails the costs of the policy. In theory, a policy θ exists where marginal benefits equal marginal costs:

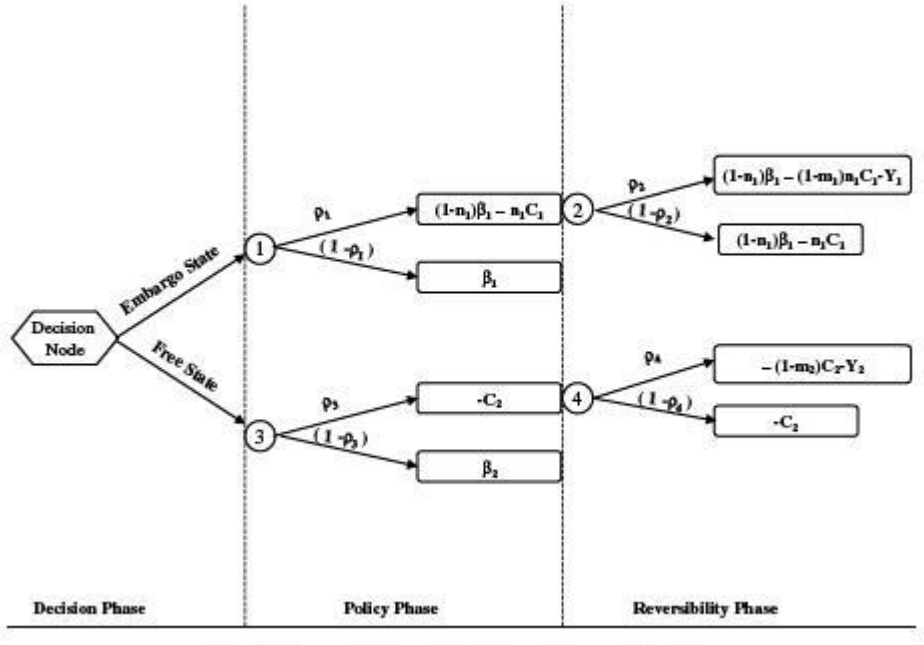
$$\left[\frac{\partial P}{\partial \theta} (W_1 - W_0) + \left(\frac{\partial W_1}{\partial \theta} + \frac{\partial W_0}{\partial \theta}(1 - P) \right) \right] e^{-\lambda T} = \frac{\partial C_0}{\partial \theta} \qquad (3)$$

The derivative of (3) with respect to λ and T are both negative. The longer the wait is, the smaller the benefits and the greater the time discount (interpreted as society's eagerness for cloned meat), the greater the reduction in benefits. If consumers are indifferent then λ can be small and no harm is done by waiting, but if λ is high then waiting causes harm.

As pointed out before, aside from scientific uncertainty, also irreversibility plays a role in justifying the precautionary principle. If the European Union would allow products obtained from cloned animals to enter the food chain and consumers start to like them because the products are cheap and tasty and producers have a vested interest in keeping these products on the market, it will be very difficult to reverse the measure when for example it becomes clear that those products are carcinogenic. Think for example how

difficult it is to persuade people from the dangers of tobacco and asbestos and imagine pictures from dying people on your milk carton.

Figure 2: Irreversibility and the precautionary approach



Source: Turvey and Mojduska (2005)

Turvey and Mojduszka (2005) analysed the relationship between irreversibility and the precautionary principle. Here, the upper path in Figure 2 represents an EU embargo on the entree of products from cloned animals in the food chain. At node (1) an intended consequence β_1, for example food safety or consumer preference, is realized with probability $(1 - \rho_1)$. However, a probability ρ1 exists that cloned food is safe or that consumers are indifferent between both food categories. If ρ_1 occurs the proportion of the EU population that has an interest in the sales of cloned products, for example cattle breeders, n_1, is negatively affected. The welfare loss in the EU is given by: $(1 - n_1)\ \beta_1 - n_1C_1$ where $(1 - n_1)\ \beta_1$ represents the benefits to the portion of the population that is against the commercialization of cloned products and n_1C_1 entails the cost to the population in favour of cloned products.

At a later stage, when scientific certainty about the safety of cloned products has increased, a probability ρ_2 exists that the EU repeals the precautionary policy and liberalises the market. In that case, a portion of the welfare of the cloning supporters, m_1, can be restored. Still, a welfare cost Y_1 will be inflicted because, for example, EU

producers might lose comparative advantages vis-à-vis their US competitors who gained experience in cloning techniques during the EU moratorium period. The net welfare of reversing the policy is then $W_{11} = (1 - n_1)\ \beta_1 - (1 - m_1)\ n_1C_1 - Y_1$ with conditional probability $\rho_1\rho_2$. If the EU decides not to reverse her embargo state policy the net welfare is $W_{12} = (1 - n_1)\ \beta_1 - n_1C_1$ with conditional probability $\rho_1\ (1 - \rho_2)$. The expected welfare from the embargo state is

$$W_1 = \rho_1\beta_1 + \rho_1\rho_2\ [(1 - n_1)\ \beta_1 - (1 - m_1)\ n_1C_1 - Y_1] + \rho_2\ (1 - n_1)\ C_1. \qquad (4)$$

The lower path in this analysis represents a European free state where cloned products are free to enter the food chain. At node (3), scientific certainty reveals that economic benefits β_2 will occur with probability $(1 - \rho_3)$. There, however, always exists a probability ρ_3 that cloned products are unsafe. This will afflict the whole population, resulting in a social cost C_2. If the cost is reversible, society will have to invest Y_2 in, for example, research and development so that a portion of the population, m_2, can recover. The net welfare impact of reversibility, W_{21}, is then the proportion of the population that recovers m_2C_2, minus the inflicted social cost C_2 and the recovery cost Y_2, or $W_{21} = -\ (1 - m_2)\ C_2 - Y_2$ with conditional probability $\rho_3\rho_4$. When the consequences of the free state decision are irreversible, the welfare impact is $W_{22} = -\ C_2$ with probability $\rho_3\ (1 - \rho_4)$. Turvey and Mojduszka (2005) write the expected welfare from the free state decision as:

$$W_2 = (1 - \rho_3)\ \beta_2 - \rho_3\rho_4\ ((1 - m_2)\ C_2 + Y_2) - \rho_3\ (1 - \rho_4)\ C_2. \qquad (5)$$

According to this approach, the implementation of an EU moratorium on cloned products was a good decision if the welfare in the embargoed state is higher than in the free state ($W_1 > W_2$). Suppose that the American FDA is correct in stating that the consumption of products derived from cloned animals is as safe as the consumption of their traditional counterparts. This implies that there is no chance on possible health risks ($\rho_3 = 0$). The benefit of the EU free state then equals the economic benefits ($W_2 = \beta_2 > 0$), occurring with a probability 1.0. Then the intended consequence of the EU decision, namely food safety or consumer preference β_1, was an imaginary benefit and equals zero in reality. Consequently, the expected costs of the EU embargo $\rho_2\ (1 - n_1)\ C_1 - \rho_1\rho_2\ [(1 - m_1)\ n_1C_1 - Y_1]$ have to be weighted against the economic benefits of the free state, β_2.

From this, the significance of reversibility becomes clear. Assume that, as soon as scientific certainty has increased, the EU liberalises the market with a probability $\rho_2 = 1$ and that hereby the complete loss in welfare of the cloning supporters can be restored ($m_1 = 1$). Then only the losses of comparative advantage, Y_1, and the loss of waiting, β_2, remain. The welfare loss of the precautionary approach can be consequently estimated as it equals $\beta_2 + Y_1$.

Model 2: Moral concerns

Even when scientific evidence in the future proves that cloned meat products are as safe as their traditional counterparts, European consumers may perceive the quality of cloned products as inferior to the quality of their clone-free equivalents. This assumption is based on the moral concerns of the European consumers and the belief that people in Europe "*prefer traditional products, not because they are safer but because they were always there.*"[45] Galli states that this stance is so well established that people are reluctant to eat biotech products. For reasons of simplicity, the analysis is limited to a two-country analysis (US and EU) and restricted to meat. The same reasoning, however, applies for eggs and dairy products.

The purpose of this economic analysis is to estimate the effects of trade liberalisation on European welfare, which is defined as the sum of consumer and producer surplus. Consumer surplus equals "*the difference between the total value that consumers place on all units consumed of a commodity and the payment that they must make to purchase that amount of the commodity.*"[46] Producer surplus denotes "*the total revenues received by producers minus the total variable cost of production.*"[47] The model addresses the changes in European welfare for four different situations: (1) EU moratorium on cloned meat, (2) trade liberalisation between the US and the EU in the meat sector without a quality label, (3) trade liberalisation while some member states allow livestock cloning and (4) trade liberalisation with a quality label.

[45] Galli, Cesare (2004:52)
[46] Lipsey, Richard, Paul Courant, and Christopher Ragan (1999:145)
[47] Idem p.279

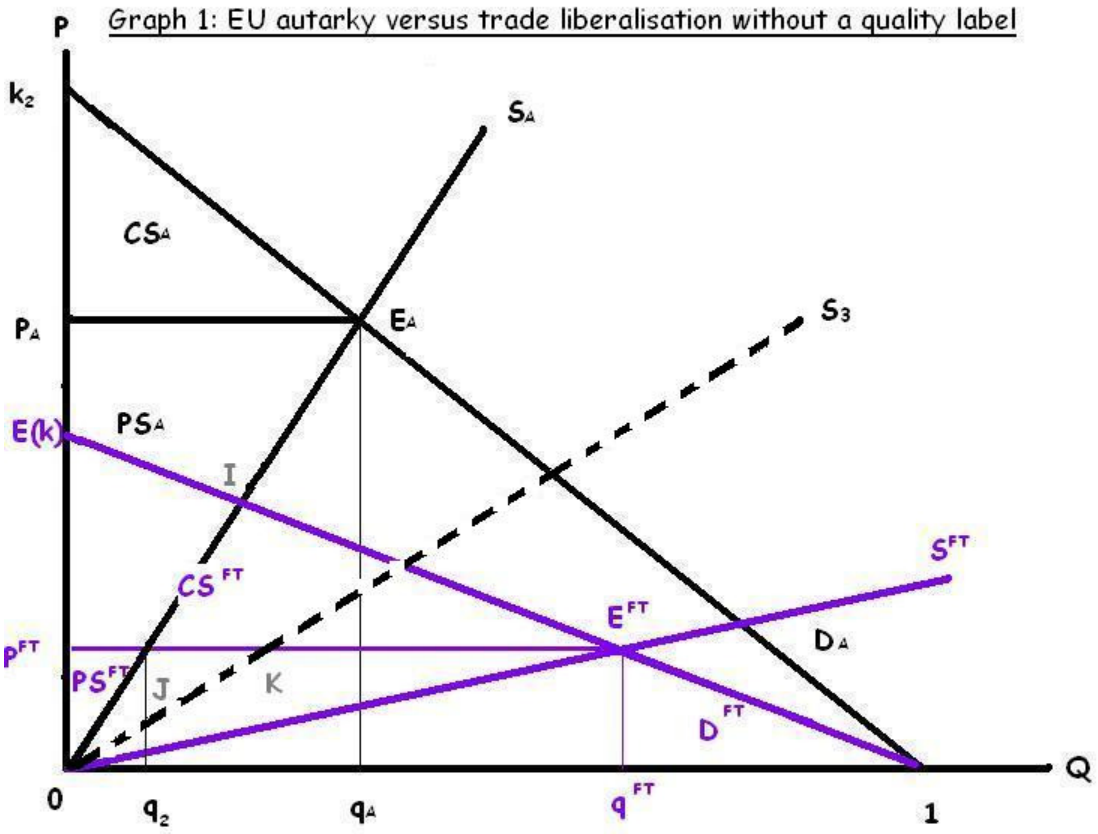
Situation 1: EU moratorium on cloned meat

In the autarky situation, there is only clone-free meat available on the EU market. Endorsed by the EU prohibition on cloned meat, European consumers believe that their governments only permit meat of the highest quality (k_2). This leads to the meat demand curve of European consumers $D_2(p) = 1 - p_2/k_2$. The meat supply of European producers is limited to $S_2(p) = p_2/c_2$.

In these equations, p_2 denotes the price the threshold consumer would pay for a certain amount of clone-free meat and c_2 indicates the variable production cost for the same amount of meat. For reasons of straightforwardness, all other costs and subsidies are ignored. In equilibrium, supply equals demand, thus, the equilibrium price under autarky p_2^A, and the quantity sold q_2^A amount:

(1) $$p_2^A = \frac{c_2 k_2}{c_2 + k_2} \qquad q_2^A = \frac{k_2}{c_2 + k_2}$$

Graph 1: EU autarky versus trade liberalisation without a quality label



In Graph 1, the surplus of European producers (PS^A) equals the triangle $OE^Ap_2{}^A$. The European consumers' surplus (CS^A) corresponds to the triangle $p_2{}^AE^Ak_2$. The European welfare in the autarky situation (W^A) is the sum of both triangles[48]:

$$(2) \qquad PS^A = \frac{p_2 q_2}{2} = \frac{c_2 k_2^2}{2(c_2 + k_2)^2}$$

$$(3) \qquad CS^A = (k_2 - p_2)\ \frac{q_2}{2} = \frac{k_2^3}{2(c_2 + k_2)^2}$$

$$(4) \qquad W^A = PS^A + CS^A = k_2\ \frac{q_2}{2} = \frac{k_2^2}{2(c_2 + k_2)}$$

In this autarky situation, European producers benefit since they steer clear of American competition. European consumers, on the other hand, lack a choice between traditional meat and cheaper American cloned meat. Economic theory predicts trade liberalisation can increase welfare because a category of consumers will prefer cheap cloned meat above the more expensive European clone-free meat.

Situation 2: Trade liberalisation without labelling

In the second situation, the European Union liberalizes its market for cloned American meat, without introducing a label because it may stigmatize the product or it may be economically unfeasible or simply impossible to distinguish the products. Since consumers cannot make a distinction between the two types of meat, there is a single demand curve D(p) and total supply S(p) is equal to the sum of domestic supply $S_2(p)$ and American exports $S_1(p)$.

Without a label, US producers have no means of signalling the European consumers that they also produce clone-free meat. Therefore, it is assumed that they base their exports purely on variable production costs. Assuming the variable production cost of cloned meat (c_1) is lower than the cost of clone-free meat (c_2), US producers have no incentive to export clone-free meat. Consequently, American supply is represented by a function $S_1(p) = p/c_1$, with p the threshold price a European consumer would pay for meat on a liberalized market without a quality label.

[48] Keep in mind that the surface area of a triangle equals the base multiplied by the height and divided by two.

European consumers, however, believe the quality of cloned meat to be lower than the quality of clone-free meat. As a result, they perceive the average quality of meat on the liberalized EU market as lower than the quality (k_2) in the autarky situation. The expected quality E(k) under trade liberalization depends on the shares of American exports $S_1(p)$ and domestic production $S_2(p)$ in total meat supply:

(5) $$E(k) = \frac{S_1(p)}{S_1(p)+S_2(p)} k_1 + \frac{S_2(p)}{S_1(p)+S_2(p)} k_2$$

(6) $$D(p) = 1 - \frac{p}{E(k)}$$

(7) $$S(p) = S_1(p) + S_2(p) = p/c_1 + p/c_2 \qquad \text{with } c_1 < c_2$$

(7) in (5) $$E(k) = \frac{c_2 k_1 + c_1 k_2}{c_1 + c_2}$$

Clearing of the market results in the equilibrium price p^{FT} and the quantity supplied q^{FT} under trade liberalisation without a quality label. The quantity supplied by the European producers (q_2) is obtained by equalizing domestic supply and demand:

(8) $$p^{FT} = \frac{E(k)c'}{E(k)+c'} \qquad q^{FT} = \frac{E(k)}{c'+E(k)} \qquad \text{with } c' = \frac{c_1 c_2}{(c_1+c_2)}$$

(9) $$q_2 = \frac{E(k)c'}{c_2(E(k)+c')}$$

The European producer surplus PS^{FT} corresponds to triangle OJp^{FT} in Graph 1. This means the EU producers lose an amount of profits equal to the trapezium $p^{FT}JE_Ap_A$ compared to the autarky situation. The surplus of European consumers CS^{FT} coincides with area $E(k)p^{FT}E^{FT}$. European welfare W^{FT} is equal to the aggregate of producer and consumer surplus:

(10) $$\text{European } PS^{FT} = \frac{p_{FT} q_2}{2} = \frac{c'^2 E(k)^2}{2c_2(c'+E(k))^2}$$

(11) $$CS^{FT} = \frac{E(k) - p_{FT}}{2} q^{FT} = \frac{E(k)^3}{2(E(k)+c')^2}$$

(12) $$\text{European } W^{FT} = PS^{FT} + CS^{FT} = \frac{E(k)^3 c_2 + E(k)^2 c'^2}{2c_2(c'+E(k))^2}$$

Graph 1 shows that trade liberalisation without a quality label has two effects on European welfare. First, people expect a lower quality which results in a decrease in price and demand for the domestic production. This effect corresponds with a shift from E_A to I. Second, the lower American production costs cause the price to decrease even more (shift from I to E^{FT}). In this situation, European welfare increases when area JIE' is larger than area $E(k)IE_Ak_2$. In other words, an increase in European welfare can be expected when trade liberalization corresponds with a relatively large decrease in variable production costs and a relatively small decrease in the quality expected by European consumers.

In order to determine the welfare effects of trade liberalisation without a quality label, we need to estimate the difference between the quality of clone-free meat k_2 perceived by European consumers and the expected quality E(k) of European consumers under trade liberalisation, on the one hand, and the difference between the variable production cost of American cloned meat c_1 and the variable production cost of European meat c_2, on the other hand.

Situation 3: Trade liberalisation when some member states allow cloning

Since legislation on ethical issues belongs to the national authorities, the possibility exists that the EU member states will set up their own animal cloning legislation. Some member states, where agriculture still plays an important role, may want to level the playing field by allowing their domestic producers to use the same technology as their US competitors. The farmers in these countries are then able to produce cloned meat at a variable cost c_1^{EU} which is lower than the cost of clone-free meat c_2 but higher than the cost c_1^{US} of US producers because the US is expected to have a cost advantage in livestock cloning ($c_2 > c_1^{EU} > c_1^{US}$).

The total supply of European meat is now the sum of the EU clone-free production and the production of cloned meat in some member states. This results in a flatter supply curve, represented by the dotted line S_3 in Graph 1, and an increase in European producers' surplus at the expense of US producers. This increase corresponds with area

OJK and depends on the relative competitiveness of EU cloned meat compared to US cloned meat c_1^{EU}/c_1^{US}.

The overall effect is however not unequivocally positive. The higher share of cloned meat in the European food chain will translate in a lower perceived quality by the European consumers, and thus a flatter demand curve and a lower market price. This lower price will increase consumer surplus but the flatter demand curve will have a negative effect on consumer surplus. The lower market price will also limit the increase in EU producer surplus.

Situation 4: Trade liberalisation with a quality label

The fourth situation addresses the case where trade gets liberalised and the EU imposes a label of quality for their meat. This induces a labelling cost L for the EU. We assume that American producers cannot have access to the label because it is impossible for the EU to distinguish between cloned and clone-free US meat as the EU has no access to US production facilities. Since there are now two products available on the market, Graph 2 shows the following two demand and supply curves:

(13) $D_1(p_1) = \frac{p_2 - p_1}{k_2 - k_1} - \frac{p_1}{k_1}$ $S_1(p_1) = p_1/c_1$ for cloned meat

(14) $D_2(p_2) = 1 - \frac{p_2 - p_1}{k_2 - k_1}$ $S_2(p_2) = p_2/c_2$ for clone-free meat

Equilibrium prices p_1^L and p_2^L and quantities sold q_1^L and q_2^L for respectively cloned and clone-free meat are then found by equalising demand and supply:

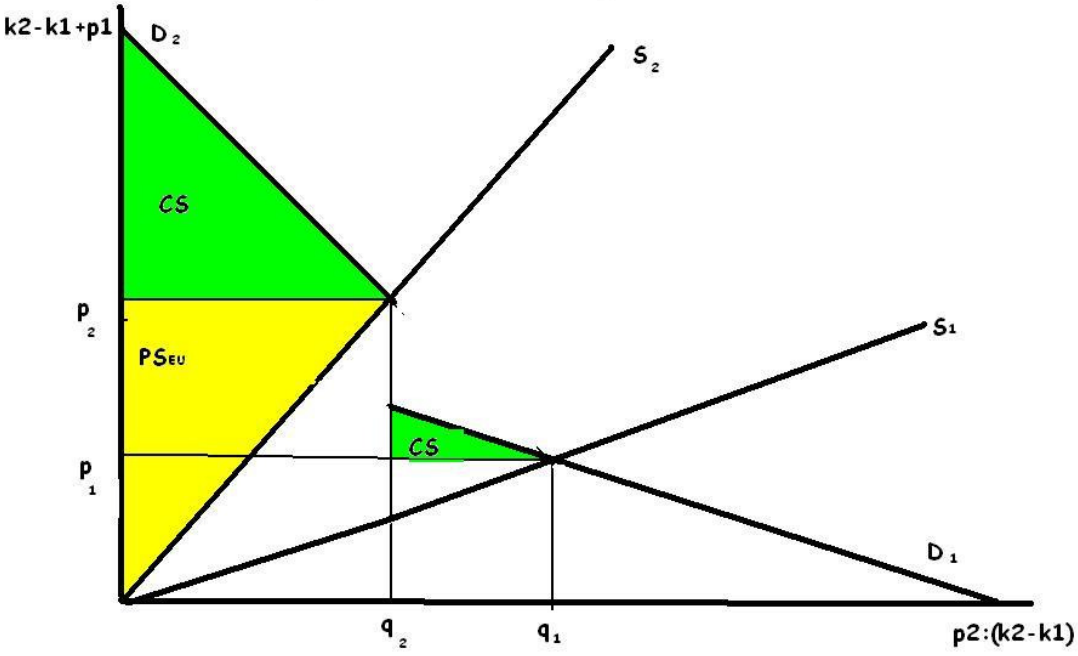
(15) $p_1^L = \frac{c_1 k_1 p_2}{c_1 k_2 + k_1 k_2 - k_1^2}$ $q_1^L = \frac{k_1 p_2}{c_1 k_2 + k_1 k_2 - k_1^2}$

(16) $p_2^L = \frac{c_2(k_2 - k1 + p_1)}{k_2 - k_1 + c_2}$ $q_2^L = \frac{k_2 - k_1 + p_1}{k_2 - k_1 + c_2}$

European consumers will prefer to buy clone-free meat until the difference in price between the two sorts of meat is large enough to offset the difference in perceived quality and moral concerns. As of that moment, indicated by point (p_2, q_2) in Graph 2,

European consumers will substitute clone-free meat for cloned US meat. Consequently, the European consumer surplus (CS^L) consists of the two green triangles in Graph 2.

Graph 2: liberalization with quality label



The European producer surplus (PS^L) is limited to the yellow triangle. European welfare W^L is the sum of consumer and producer surplus minus the labelling cost (L):

$$(17) \quad PS^L = \frac{p_2 q_2}{2} = \frac{c_2(k_2 - k_1 + p_1)^2}{2(k_2 - k_1 + c_2)^2}$$

$$(18) \quad CS^L = (k_2 - k_1 + p_1 - p_2)\frac{q_2}{2} + \int_{q2}^{q1}\left(\frac{p_2 - p_1}{k_2 - k_1} - \frac{p_1}{k_1} - p_1\right)dq$$

$$= \frac{(k_2 - k_1 + p_1)^2(k_2 - k_1)}{2(k_2 - k_1 + c_2)^2} + \int_{q2}^{q1}\left(\frac{p_2 - p_1}{k_2 - k_1} - \frac{p_1}{k_1} - p_1\right)dq$$

$$(19) \quad W^L = PS^L + CS^L - L$$

The European producer surplus is smaller than the producer surplus under autarky due to US competition.[49] The European consumer surplus has increased because consumers can chose between both qualities. Consequently, European welfare under trade liberalisation with a quality label is higher than welfare under autarky when the increase

[49] Calculations show that $PS^A > PS^L \Leftrightarrow p_1, c_2$ and $(k_2 - k_1) > 0$. Since variable production costs and prices are always positive and we assumed that consumers perceive the quality of clone-free meat as higher than the quality of cloned meat, producer surplus under autarky is always larger than under trade liberalization with a quality label.

in consumer surplus compensates the loss in producer surplus and the labelling cost. To calculate the welfare effect, we need to estimate the ratio of the meat prices p_1^L/p_2^L, the variable production costs c_1 and c_2, the perceived qualities k_1 and k_2 and the labelling cost L.

Conclusion

European farmers will suffer important losses when the EU allows importation of cloned meat while maintaining a domestic prohibition on livestock cloning. Therefore, some member states may want to level the playing field by claiming that animal cloning is ethically justified. It is obvious this would have serious consequences on the free movement of cloned meat products within the EU and lead to unfair competition. Cloning legislation is therefore best taken at the EU level although "*consensus across the EU on aspects other than risks to human health and the environment does not seem likely*."[50]

European consumers will benefit from livestock cloning if the EU imposes a label so that consumers can distinguish between cloned and clone-free products. The precondition is however that the labelling cost does not result in important price increases. When the EU or some member states allow cloned products to enter the food chain without a quality label, welfare losses for the European consumers will prevail unless a relatively large decrease in production costs is translated into an important price reduction. This is also an important prerequisite for livestock cloning to become morally acceptable.[51]

The overall effect on European welfare depends on the size of the differences in perceived quality, variable production costs and prices of both products and the possible labelling cost. Differences in perceived quality could be estimated by a stated choice survey[52] or by organising an experimental auction market[53]. Moreover, the European Commission is currently drafting a financial model, at the pig sector level, indicating

[50] CeBRA (2006d:10)
[51] GAEIB (1998: Art. 2.5)
[52] See for example Alfnes, Frode (2001)
[53] See for example Alfnes, Frode and Kyrre Rickertsen (2003)

the potential benefits to pig producers and effect on consumer prices.[54] Differences in production costs and consumer prices could possibly be based on this study.

4. Discussion

This study has shown that livestock cloning still is confronted with some moral concerns and food safety risks. In this light, it can be expected that the EU currently finds cloning for agricultural purposes a bridge too far and will respond in such a way that farm animal cloning will not be taken-up immediately in Europe. In order to have an accurate view of the EU policy approach, it is necessary to await the conclusions of the risk assessment of the European Food Safety Agency and the Opinion of the European Group on Ethics in Science and New Technologies on the Ethical Aspects of Animal Cloning for Food Supply.

The most effective method for the EU to establish an effective prohibition on livestock cloning would be to make some minor adaptations to the existing EU legislation. This prohibition would be in line with WTO obligations as the GATT and the SPS Agreement permit import restrictions for products that cause moral concerns or can harm public health. It can thus be expected that the EU prohibition will survive possible attacks under the Dispute Settlement Mechanism of the WTO.

When the EU prohibits livestock cloning until it is absolutely certain that the consumption of products from cloned animals is as safe as their traditional counterparts, the EU will endure a direct welfare cost equal to the aggregate of the forgone market benefits and the loss in comparative advantage compared to countries who take up livestock cloning immediately. There exist however also some indirect consequences for EU welfare as a part of the European public may perceive the quality of traditional meat to be higher than cloned meat because of ethical objections concerning livestock cloning. The overall effect on European welfare then also depends on the size of the differences in perceived quality, variable production costs and prices of both products and on the possible labelling cost.

[54] Papatryfon, Ilias. "Re: Animal cloning and genetic modification: a prospective study." E-mail to author. 27 Jun 2007.

These quantities can be calculated in future research. Differences in perceived quality could, for example, be estimated by conducting a stated choice survey or by organising an experimental auction market. In addition, the European Commission is drafting a financial model, at the pig sector level, indicating the potential benefits to pig producers and the effect on consumer prices. Differences in production costs and consumer prices could possibly be based on this study. The labelling cost mainly depends on the technical possibilities to distinguish cloned products from their traditional counterparts.

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