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Koen Dillen, Emanuele Ferrari, Pascal Tillie,
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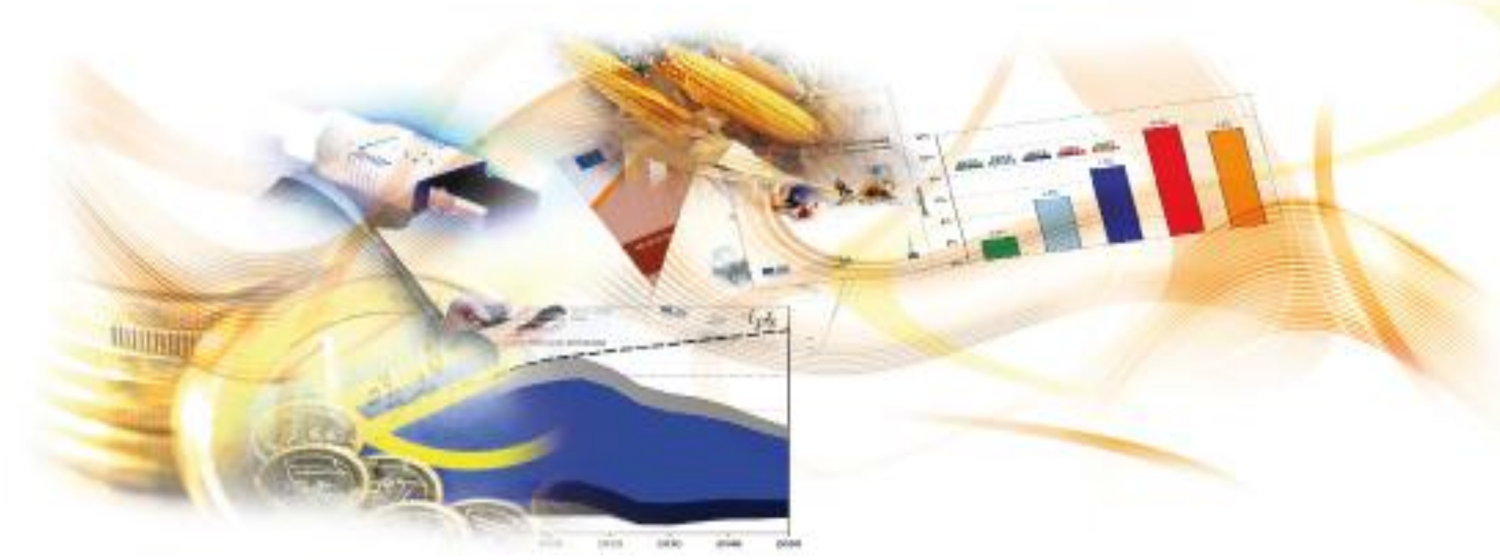
2013



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Abbreviations and Acronyms

ACP African Caribbean and Pacific
Bn billion
CAP Common Agricultural Policy
CAPRI Common Agricultural Policy Regionalized Impacts
CES constant elasticity of substitution
CET constant elasticity of transformation
CGE computable general equilibrium
EC European Commission
EFSA European Food Safety Authority
EP European Parliament
EU European Union
EU27 EU defined by its membership since 2007 (EU15 + EU12) and before the accession of Croatia on July 1st, 2013
EFSA European Food Safety Authority
GAMS General Algebraic Modelling System (software package)
GTAP Global Trade Analysis Project
ha hectare
LDC least developed country
mn million
NPV Net Present Value
NUTS 2 Nomenclature of Territorial Units for Statistics (*nomenclature d'unités territoriales statistiques*), Level 2
PE partial equilibrium
RoW 'Rest of the World'
SAM social accounting matrix
Tec tons equivalent carcass
TFP total factor productivity
TRQ tariff rate quota
US United States of America
VA Value Added
WTO World Trade Organisation

Executive Summary

The European Commission is currently conducting an Impact Assessment process to evaluate different policy options towards the use of the cloning technique for animal reproduction and the incorporation of products derived from cloned animals in the food chain of the European Union. In the context of this Impact Assessment, the JRC was requested to simulate via a modelling exercise the economic impacts of selected policy options that could result in *de facto* trade disruptions. This study presents a first attempt to quantify the likely effects of different policy measures for animal cloning for food production on the international trade and the EU domestic markets particularly on production and prices.

In the crops and livestock sector, the potential of animal cloning consists of securing the spread of desired genetic characteristics compared to traditional breeding techniques. This translates into increased productivity over time. Most studies available in the literature focus on the dairy sector as the commercial potential for cloning is considered to be high for this activity. The present study therefore focuses on specific simulations for cattle and milk production and the corresponding downstream sectors, beef and dairy.

Based on a literature review and after considering the specific objectives of this study, the choice was made to perform the analysis employing a Computable General Equilibrium (CGE) model called GLOBE. Different model scenarios were constructed based on combinations of the discussed policy options such as a ban, or traceability and labelling requirements with associated productivity increases arising from the use of the cloning technique.

The first scenario (scenario 1 of the present study), assumes that all countries will adopt cloning and no restrictions to trade exist. The results show that the impact of cloning on productivity, both inside and outside of the EU, is limited. Cloning increases productivity and hence ameliorates the competitive position of those sectors having access to the technology, leading to a slight increase in domestic production. However, as all countries are assumed to gain from cloning, the trade effects are small.

A further scenario (scenario 3 of the present study[1]) assumes that the EU prohibits the use of cloning but not the imports of derived products, while some of its trade partners use the cloning technique. We assume that the US, Argentina, Brazil and New Zealand adopt the technology as they signed a joint statement on the topic. Under the assumptions of this scenario, no trade restrictions exist and the difference lies in the productivity increase associated to the use of cloning in some countries although not in the EU. The results show that in this case the EU would import marginally more cattle, beef and dairy, but the effects on prices and domestic production would be negligible as imports represent only a small part of the EU domestic use.

In a following scenario (scenario 4 of the present study), traceability and labelling are added as a requirement for imports from countries using the cloning technology. This requirement leads to a slight reduction in imports, as the increased costs of the traceability system offset the benefits from the technology. Again the changes are too small to lead to any significant production or price effects in the EU's domestic market.

Finally, a last scenario (scenario 5 of the present study) is built on the assumption that imports of cattle, beef, milk and dairy products from countries using the animal cloning technique come to a halt due to express prohibitions or a *de facto* decision by exporters. In this scenario the effects are more pronounced. A first direct effect is a shift in the sources of imports into the EU. If imports

[1] Scenario 2 corresponds to a policy option that is not modelled in this report. It is a combination of scenarios 1 and 3 and therefore its results would have been similar to those of both scenarios.

from Brazil, US, Argentina and New Zealand are suspended, Canada and Australia would increase their exports to the EU, responding to its demand. The substitution effect is, however, not complete. The total reduction in imports would be significant with a 50%-drop in the imports of cattle and beef compared to the baseline and a 20% decrease in dairy imports. This reduced availability of imports for the EU would lead to an increase in import prices. For cattle and beef, import prices would rise by approximately 10% while the price increase for dairy would be much smaller (about 1%).

The reduction in imports under this last scenario would be partly compensated by increased EU domestic production. Cattle production is expected to grow by about 4% while the beef sector would grow by slightly more with 6%. These changes are small as the share of imports represents a relative small part of EU domestic consumption. The value of this expanded domestic production is however significant as it represents about USD 4.28 billion. The expansion in production is accompanied by a slight increase in producer prices. A similar chain of events can be expected in the milk and dairy sector. However, as both the reduction in imports and the share of imports in total production are smaller, the effects on domestic production are less pronounced.

The production expansion in the EU due to the *de facto* ban on meat and dairy imports from some countries has an effect on the upstream sectors. The demand for fodder increases by 4% leading to a small price increase in other land-based production systems such as cereals and grains.

The changes in production and prices also have a downstream effect. The EU consumers will experience a price increase as domestic production cannot fully compensate for the loss of imports. The price effect is most pronounced in the beef sector where it amounts to about 2%. For cattle, milk and dairy the price effects are much smaller, not surpassing 1%. The price of other meat products, mainly poultry and pork, increases marginally through a combination of substitution and price increases in the input markets. All these price effects combined lead to a welfare loss of about USD 1.7 billion in the case the EU ban (or a *de facto* interruption) of imports from countries using the cloning technology.

Finally, this report highlights the need for further specific analysis to understand the impacts in certain niche markets or to investigate the response of individual countries to the EU's requirements for traceability and labelling.

1. Introduction

In its report of 2010, the European Commission (EC) has proposed the following measures on animal cloning for food production:

- Suspend temporarily the use of the cloning technique in the EU for the reproduction of all food-producing animals including the use of clones of these animals and import of clones and marketing of food from clones.
- Establish traceability of imports of semen and embryos allowing farmers and industry to set up data banks of offspring in the EU.

The European Commission is currently carrying out an impact assessment to examine a comprehensive set of possible measures on animal cloning for food production so that it can propose legislation.

This JRC report, as a contribution to this impact assessment process, provides insights into the effects of different policy scenarios on international trade and competitiveness based on an economic simulation model.

The study focuses on four scenarios:

- The assumption that all countries will adopt cloning and no restrictions to trade exist.
- The assumption that the EU bans the use of cloning but not the imports of derived products, while some of the trade partners accept cloning.
- The assumption that traceability and labelling are added as a requirement for imports from countries using the cloning technology.
- Finally, the assumption that imports of cattle, beef, milk and dairy products from countries using cloning come to a halt (due to express prohibitions or a de facto decision by exporters).

2. Modelling approach

2.1. Economic simulation models

Quantitative analysis of policy options make an important contribution to the policy-making process as is acknowledged in the EU's Impact Assessment guidelines of the EU. This is particularly the case in agricultural and rural development policies, as well as related topics such as trade, energy, environment, and climate change.

Economic simulation is one of the tools to perform these quantitative analyses. Economic simulation models depict the interrelationships between selected economic variables and, as such, provide a simplified but clearly structured and quantified representation of economic reality that can be used ex ante to analyse the impacts of policy changes. Such models are widely applied in the analysis of the agricultural sector as provider of food, feed, fibre and now, increasingly, energy, but also of its role in the rural economy and of the environmental effects linked to agricultural production. Ex post analysis of policies typically demands an evidence-based assessment, and therefore stylised economic simulation models like those described in this document are less commonly used.

The integrated Modelling Platform for Agro-economic Commodity and Policy Analysis (iMAP) is hosted by the European Commission's Joint Research Centre, Institute for Prospective Technological Studies in Seville. iMAP was created to provide a scientific basis for policy decision-making addressing a broad range of topics linked to the economic assessment of the Common Agricultural Policy (CAP) and related topics such as trade, energy, environment, and climate change (Mbarek *et al.*, 2012). The platform contains selected partial equilibrium and general equilibrium models used in stand-alone mode or in combination. Following the results from the literature review a CGE model was chosen. The GLOBE model was chosen as the appropriate tool for this explorative study because of its coverage of different sectors and the possibility to obtain results in a limited timeframe.

2.2. GLOBE

GLOBE (McDonald *et al*., undated) is a member of the family of Computable General Equilibrium models. A computable general equilibrium (CGE) model is a system of nonlinear simultaneous equations representing the constrained optimising behaviour of all agents within the economy as producers, consumers, factor suppliers, exporters, importers, taxpayers, savers, investors, or government. This means that it depicts the production, consumption, intra-sectorial input and trade of all economies for one country, a region or even all countries worldwide.

GLOBE is a Social Accounting Matrix (SAM)-based CGE model calibrated with data from the Global Trade Analysis Project's (GTAP) database version 8 (Aguiar *et al*., 2012)[2]. GLOBE incorporates various developments in CGE modelling over the last two decades. The model owes a particular debt to the IFPRI standard model (Löfgren *et al*., 2002) and the PROVIDE Project model (McDonald, 2003), as well as to the GTAP model (Hertel, 1997). The model is written and solved using the General Algebraic Modeling System (GAMS) software.

GLOBE consists of a set of single country CGE models linked by their trading relationships. Price systems are linearly homogeneous and thus only changes in relative prices matter. Consequently each region in the model has its own *numéraire* price, typically the consumer price index (CPI) and

[2] For the underlying principles of GLOBE, see de Melo and Robinson (1989) and Devarajan *et al*. (1990); for earlier models that can be described as its antecedents, see Robinson *et al*. (1990, 1993).

a nominal exchange rate, while the model as a whole requires a *numéraire*, which is an exchange rate index for certain reference regions[3]. In this implementation of GLOBE, the reference region is the US.

The SAM on which GLOBE is based disaggregates each region's economy according to seven families of 'accounts': commodities, activities, production factors, margins, taxes, institutions and capital investment. The neoclassical behavioural relationships are standard for global a CGE model. Activities maximise profits using technology characterised by Constant Elasticity of Substitution (CES) production functions over primary inputs (skilled and unskilled labour, capital, land and natural resources) and Leontief production functions across intermediate inputs (no substitution allowed among intermediate inputs). The household maximises a Stone-Geary utility function (which assumes a linear expenditure system after payment of income tax and after saving a share of post-tax income). The Armington (1969) assumption is used for trade, which implies that domestic and imported commodities are not homogenous goods, in other words imported goods form different regions are imperfect substitutes of each other and of domestic production. Domestic output is distributed between the domestic market and exports according to a two-stage Constant Elasticity of Transformation (CET) function. In the first stage, domestic producers allocate their output between the domestic and export markets according to the relative prices for the commodity on the domestic market and the composite export commodity (which is a CET aggregate of the exports to different regions). The distribution of the exports between regions is determined by the relative export prices to those regions. Hence domestic producers respond to prices in all markets for the product. The elasticities of transformation are commodity- and region-specific[4]. The typical assumption related to substitution elasiticites is that the elasticities in the second stage are double those in the first stage. Domestic demand is satisfied by composite commodities that are constructed by means of a three-stage CES function from domestic production sold domestically and composite imports. All commodity and activity taxes are expressed as *ad valorem* tax rates, while income taxes depend on household incomes (see Appendix Table A1.3 for a summary of these behavioural relationships in GLOBE).

For the purpose of this study, GLOBE distinguishes 15 product categories across the whole economy (see Annex Table A 1). All product categories are agricultural or food-related except four: primary products[5], manufacturing, services and 'trade'[6]. This limited amount of product categories makes it impossible to differentiate between cattle, sheep, goat and horses and their respective meat production or to make the difference between different dairy products. As cattle and beef meat take the lion's share of production and trade for most countries, we use the classifiers cattle and beef in the remainder of the text. The reader should however keep in mind that these categories of product contain more than just bovine products. Where this aggregation may have an important effect on the interpretation of the results, the analysis is deepened through the use of secondary data sources.

The EU is treated as a single region (EU27[7]). In addition, 12 other regions are separately identified based on their importance for EU trade (see Annex Table A 2). GLOBE also contains an artificial 'dummy' area (Globe) that absorbs inter-regional trade flows where either the source or destination is not identified (for example, some trade and transportation margins and data on remittances). This construct provides a general method for dealing with any transactions data where full bilateral information is missing (see McDonald *et al*., undated).

[3] This represents a fundamentally different philosophical approach to global modelling from that of the GTAP model, which does not contain nominal exchange rates and has a single global *numéraire*.
[4] In GTAP, the elasticities are commodity-specific only. When the CET functions across exports are switched off so that export supplies are determined by import demands, the model functions similarly to the GTAP model.
[5] Which includes forestry, fishing and mining products.
[6] The product category 'trade' includes transport costs and other trade services, and margins.
[7] By the time this study was initiated, Croatia wasn't part of the EU yet. Therefore this whole analysis was performed at EU-27 level.

The version of GLOBE employed in this report is static, and therefore when used to simulate policy impacts in a specific future year, it is not necessary to simulate the time-path followed in the intervening time period. In order to simulate policy outcomes in 2020, the model simply requires exogenous input about the conditions expected to prevail in that year. GLOBE needs this information with respect to population and technological change[8]. In addition, other projections have to be supplied exogenously in order to construct its baseline (which provides the estimates for the reference scenario) against which the policy simulations are compared.

Policy shocks are evaluated compared to a baseline for a given year in the future. Given its assumptions on production factors and on values of elasticities, GLOBE can be defined as medium-term time frame model. In other words, they represent expected adjustments, for example redistribution of trade among regions, changes and adaptation of production patterns that are likely to take around five years. In the short term, the policy options could produce changes in import and domestic prices and changes in production which are expected to be stronger than in the medium term. However, certain additional adjustment mechanisms may work in the medium to long term, which are not fully considered by these models, and might reduce the impacts of a possible trade ban. For instance, countries using the technique of cloning could expand the segregated production of non-cloned animals for the European markets. Thus, the impacts presented in this study might lie between possible higher short-term effects and lower medium- to long-term effects.

2.3. **Alternative approaches for an extended impact assessment**

With a different time constraint (results have been requested in two-month timeline), a more detailed analysis could have been performed with these two alternative approaches:

A first approach could be to use the GLOBE model with a modified database. A revision of the GTAP database in order to disaggregate the products of interest of this study (e.g. beef-sheep) from other products could be envisaged. This disaggregation could be even further extended to differentiate between two beef products, one representing beef coming from cloned animals and one from "clone free", on the condition that sufficient information on both products is available (production, trade, etc.) This approach would allow taking into consideration consumer’s preference towards cloning and modelling segregation between the two markets.

A second alternative approach could be using bilateral trade, agricultural partial equilibrium models, e.g. CAPRI (Common Agricultural Policy Regionalized Impacts, see Witzke and Britz, 2008). Unlike GLOBE, CAPRI has both a more disaggregated breakdown of agricultural commodities (e.g. different kinds of meat products) and a more disaggregated spatial coverage within the EU (results can be displayed at NUTS2 level). This means that specificities of products, regions and policy features, particularly within the EU, can be captured in more detail.

[8] As explained later, in the GLOBE simulation assumptions about technological change are replaced by exogenous assumptions about GDP growth.

3. Background information and data

3.1. **Production and trade statistics**

3.1.1. Beef meat

As illustrated in **Table 1**, the main beef producers in 2012 were the United States, Brazil and the EU-27, which combined about half of the world production (USDA PS&D, 2012). Around 15% of the world production is traded. In 2012, close to 70% of world exports came from India, Brazil, Australia and the United States (see **Table 2**). From 2004 to 2010, Brazil was the most important world exporter but this has changed in 2011. The main reason can be found in the Brazilian economic recovery which led to a higher share of the Brazilian supply used in the domestic market while at the same time the overall production has been decreasing since 2007 (Institut de l'Elevage, 2011). In addition India, which has the biggest cattle herd in the world, is recently becoming a major player on the world market. In 2012, New Zealand was the 5th world exporter, followed by Canada, Uruguay, the EU-27 and Paraguay.

Table 1: Main producers of beef and veal meat in 2012

Producers		Production (1000T)
		2012
1.	**United States**	**11,709**
2.	**Brazil**	**9,210**
3.	**EU-27**	**7,815**
4.	China	5,540
5.	India	3,643
6.	Argentina	2,620
7.	Australia	2,140
8.	Mexico	1,815
9.	Pakistan	1,400
10.	Russian Federation	1,350
	Rest of the world	9,928
	World	57,170

Table 2: Main exporters of beef and veal meat in 2012

Exporters		Exports (1000T)
		2012
1.	**India**	**1,680**
2.	**Brazil**	**1,394**
3.	**Australia**	**1,380**
4.	United States	1,124
5.	New Zealand	521
6.	Canada	395
7.	Uruguay	365
8.	EU-27	310
9.	Paraguay	240
10.	Mexico	200
	Rest of the world	715
	World	8,324

Source: USDA PS&D (2012), data elaborated with DataM (Hélaine, 2013)

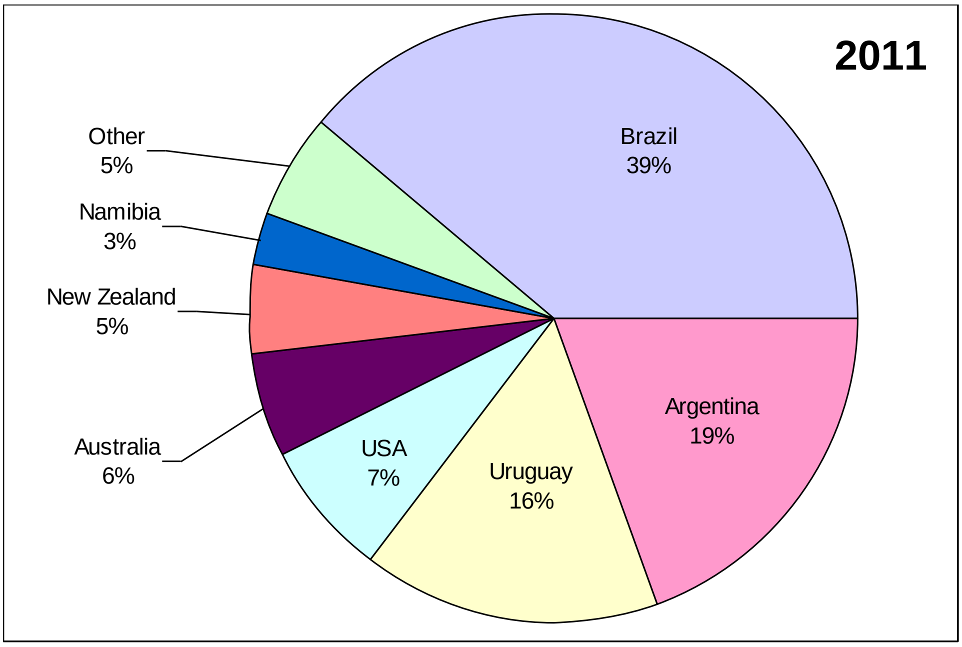
The main importers of beef are Russia, the United States, Japan, the Republic of Korea and the EU-27. EU imports of beef[9] reached 323 000 tonnes equivalent carcass (tec) in 2011 (DG AGRI, 2012). The main provider of beef to the EU is Brazil, followed by Argentina and Uruguay with respectively 39%, 19% and 16% of the market in 2011 (see **Figure 1**). Most of the imports take place within tariff rate quotas (TRQ) with preferential access. Outside of the TRQs, the duties are so high that given the current high world beef prices only small quantities of beef meat can enter the EU market.

The EU imports have been halved since 2006 and the distribution of the EU providers has changed significantly. The share of Brazil has decreased sharply for several reasons. As indicated earlier, the Brazilian production available for exports has decreased and the export price has increased. In addition, since 2008 the raw Brazilian meat exported to the EU should originate from certified

[9] Including live animals and offal trade.

farms[10] for sanitary reasons. As a consequence, in 2008 exports from Brazil to the EU decreased by 50%. In the coming years, only a slight increase of Mercosur exports to the EU is therefore expected (Fellmann, 2012). The share of the US has increased significantly in EU imports because this country can benefit from a 20 000 tonnes TRQ for beef without hormones at a zero tariff since 2009; since 2010 the same situation applies to Canada. This TRQ increased to 48 200 tonnes in August 2012. The decline of Brazil has allowed for an increased access to the EU market for Australia, New Zealand and Uruguay.

Figure 1: Share of the main beef meat exporters to the EU in 2011



Source: DG AGRI (2012)

3.1.2. Sheep and goat meat

The main world producers of sheep and goat meat are China, Oceania, the EU and India with respectively 29%, 8%, 7% and 6% of the world production in 2010 (FAOSTAT, 2012). While India, China and the EU consume almost all their domestic production, New Zealand exports 98% of it and Australia 64% (OECD, 2011).

The EU is the world's first importer of sheep meat with imports reaching 233 600 tec in 2011. The bulk of it, namely 82%, came from New-Zealand in 2011, while an additional 9% came from Australia (DG AGRI, 2012). More than three fourth of New-Zealand exports to the EU consist of sheep meat products. The EU imports have been decreasing since 2009, mainly due to a reduced production in New Zealand following bad weather conditions, to the appreciation of the New-Zealand dollar against the Euro and to an increase of New Zealand exports towards the Asian market (DG AGRI Unit C4).

3.1.3. Milk and dairy products

The EU is the first world producer of milk with 27% of the world production in 2012, followed by India and the United States (USDA PS&D, 2012). These three countries produce close to 70% of the world production of raw milk and they are also the main producers of dairy products. The

[10] In 2007 more than 10,000 Brazilian establishments were listed in the EU Traces List, at the end of 2010 there were only 2,229 and as of today 1,858 establishments are listed (Fellmann, 2012).

picture of the global trade is slightly different. The EU and the United States are still major players but the Indian production is mainly meant for the domestic market while the third main actor is New Zealand, despite the fact it produces only 4% of world milk. New Zealand is the first exporter of butter and whole milk powder (WMP), the second of cheese and the third of skimmed milk powder (SMP) (see **Table 3**). As for sheep milk, New Zealand exports almost all its production. These three countries are largely dominating the world trade.

Table 3: World exports of dairy products in 2012 (1000 tonnes)

	Butter	Cheese	SMP	WMP
New Zealand	480	275	380	1,225
EU-27	130	755	585	385
United States	47	261	455	12
World	**758**	**1,613**	**1,649**	**2,022**

Source: USDA PS&D (2012), data elaborated with DataM

The main importing countries of dairy products are spread around the world and the ranking depends on the product: Russia is the first importer of butter and cheese, China of WMP and Mexico of SMP. The EU is mainly export–oriented. However, the EU imports significant quantities of butter and cheese. In 2010, the EU imported 33 200 tonnes of butter (98% from New Zealand) and 81 100 tonnes of cheese mainly from Switzerland (58%) and New Zealand (32%) (DG AGRI, 2011).

3.2. **State of play regarding the use of cloning worldwide (EU partners)**

Limited information is available on the extent of the commercial use of cloned animals or their offspring. Most authorities stated the absence of a specific legislation governing the use of animal clones. Animal clones, their progeny and products deriving from animal clones are subject to the same regulations as conventional animals regarding food safety, animal health and animal welfare. Japan has a voluntary moratorium on the use of cloned animals and their offspring in the livestock production while in Australia an explicit industry moratorium on products of cloning entering the food supply is in place.

In 2011, the US, Argentina, Brazil, Paraguay and New Zealand signed a joined statement on animal cloning declaring that the sexually-reproduced progeny of clones are not to be considered as clones. For these countries, the progeny of cloned animals are similar to any other sexually-reproduced animal of their own species. In the remainder of this analysis we interpret this statement as the willingness of these countries to use the technique of cloning in commercial livestock production and breeding.

3.3. **Policy options discussed in the EU**

The European Commission performed an assessment of all aspects related to the introduction and/or regulation of animal cloning techniques, and stated its conclusions in a report to the European Parliament and the Council (European Commission 2010). The measures proposed by the EC in this report were: (i) Temporary suspension of the use of the technique of cloning in the EU for the reproduction of all food producing animals, the use of clones for food producing animals, the import of clones and the marketing of food stemming from clones; (ii) the establishment of a traceability system for imports of semen and embryos to allow farmers and industry to set up data bank(s) of offspring in the EU.

In the 2012 Roadmap called "Measures on animal cloning for food production in the EU", the European Commission (2012) detailed five main policy options, as a basis for discussion and analysis of their impacts in terms of costs and benefits for the various stakeholders involved in the animal production sector (private operators, public administration and consumers). These policy scenarios are summarized in Table 4. This study evaluates the impact of the presented policy options on trade and production.

Table 4: policy options for the regulation of the cloning technique by the EC in the EU

	Technology	Live animals and reproductive materials			Traceability systems			Food		Imports		
	Use of cloning technique in EU	Use of clones in EU	Use of offspring of clones in EU	Use reproductive materials from clones	Traceability for live clones	Traceability for live offspring	Traceability for reproductive materials from clones	Food from clones	Food from offspring	Reproducti ve materials (semen and embryos)	Live clones	Live offspring
Scenario 1: *status quo*	Yes	Yes	Yes	Yes	No	No	No	Yes, with pre-market authorization	Yes (same as any food)	Yes	Yes	Yes
Scenario 2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes, with labelling	Yes, with labelling	Yes, with traceability	Yes, with traceability	Yes, with traceability
Scenario 3	No[a]	No[a]	Yes	Yes	-	Not mandatory (voluntary database)	Yes	No[a]	Yes (voluntary labels)	Yes, with traceability	No[a]	Yes, voluntary database
Scenario 4	No[a]	No[a]	Yes	Yes	-	Yes	Yes	No[a]	Yes, with traceability and labelling	Yes, with traceability	No[a]	Yes, with traceability
Scenario 5: full ban	No	No	No	No	-	-	-	No	No	No	No	No

a Temporary suspension

4. Preparatory work for modelling

4.1. **Specifying the "closure rules"**

In mathematical programming terms, the model closure conditions ensure the equality between numbers of equations and variables. However, from an economic theoretic dimension, model closure rules define fundamental differences in perceptions of how an economic system operates. The closure rules relate to macroeconomic, e.g., is investment expenditure determined by the volume of savings or the other way around, and to capture typical features of an economic system, e.g., the degree of factor's mobility.

Simulations with models such as GLOBE typically adopt the so-called standard neo-classical assumptions closure rules, namely: (1) trade balance fixed and exchange rate variable, (2) fixed savings rates and investment variable ("savings-driven"), (3) government budget deficit/surplus variable and household income tax rate fixed, (4) factors of production (land, skilled and unskilled labour, capital and natural resources) fully mobile and (5) full employment of factors.

Our main criterion when specifying the closure rules was that assumptions should be reasonable and realistic, given recent trends and cross-country differences in macro-management policies. For example, regarding closure rule 1, developed country exchange rates depend not only on the trade balance but also on foreign capital movements; when significant exchange rate adjustments take place, it is more likely to be the result of several endogenous and exogenous (policy) factors rather than an automatic adjustment to changes in the trade balance. Moreover specific assumptions are made about exchange rate changes up to 2020, which would necessitate exogenous assumptions regarding exchange rate appreciation and depreciation between currencies. However, for the least developed countries, this assumption was felt to be unrealistic. Hence, a different decision regarding closure rule 1 was made for these countries. Based on previous experience and evidence, the closure regime might affect the results but the differences are minor and cannot threaten or overturn any policy implications that emerge from the results shown in the report.

In addition, rule 3 was modified in order to take into account projections on government deficit (or surplus) as % of the GDP in the future. In the chosen closure rule, the government budget deficit/surplus is fixed at its projected level while household income tax rate are endogenous and free to adjust to achieve the level of government deficit/surplus.

For simplicity, in this study the remaining closure rules (2, 4 and 5) adopt the standard neo-classical approach.

4.2. **Construction of the baseline**

To reproduce the most likely future developments of the global economy in the future, several economic variables are exogenously shocked to build a baseline for 2020. The baseline represents the business as usual scenario to which all policy scenarios are compared.

Once exogenous projections of exchange rates, trends in the availability of the five fixed factors (unskilled and skilled labour, capital, land and natural resources), population and GDP are available, GLOBE solves for all other relevant variables. In order to use an exogenous projection of GDP in the reference scenario, the model was solved assuming an endogenous technological progress to be achieved by 2020. This value was then taken as given (exogenous) in the policy scenarios, allowing GDP to be endogenously determined and hence different from the initial assumption in the presence of the different policy options. In other words, GDP is exogenously fixed in the baseline, following available projections, while it is endogenously determined by the model in the policy scenarios.

Using the comparative static version of GLOBE, it is important to recognise that all differences simulated between the base year, 2007, and the reference scenario in 2020 are due to the trends embodied in these exogenous assumptions.

For this study, GLOBE includes the explicit modelling of bilateral TRQs (Burrell *et al.*, 2012), following the approach of van der Mensbrugghe (2005). Because of time and data constraints, only bilateral TRQs offered by the EU to third countries in the beef market are modelled, and *erga omnes* (multilateral non-preferential) TRQs are converted into bilateral TRQs. Implementation of TRQs better depicts the expected movements in the beef trade market in the future.

Bilateral TRQs are modelled as a mixed complementarity problem (in this case, different solutions depending on the size of imports of a good relative to its TRQ). Three possibilities can occur:

- imports are below the quota limit: imports enter at the in-quota tariff rate,
- imports are equal to the quota limit (the quota is just binding): the domestic price of imported good is equal to the world price plus the in-quota tariff plus a premium, which is determined endogenously by the model,
- imports exceed the quota limit; the out-of-quota (MFN) tariff is applied to the quantity in excess of the quota limit. In this case the domestic price of import is equal to the world market price times the in-quota-tariff rate plus the premium. The premium is equal to the difference between in- and out-of-quota tariffs (= the quota rent).

For simplicity, the quota rent is entirely assigned to the importers. The importer’s share is treated as part of government income. In a one-household model like GLOBE, this does not create bias for the consumer welfare analysis.

5. The policy options and their specifications in the model

5.1. Baseline

No cloning technique available anywhere, this scenario will serve as a counterfactual for the other scenarios.

5.2. Scenario 1 – Cloning is allowed

The cloning technique is allowed in the EU. The cloning technique is available in third countries which signed the joint statement on animal cloning for livestock production (Argentina, Brazil, New Zealand and the US).

MODEL: Increased productivity in cattle and milk production stemming from the use of the cloning technique is assumed. The Total Factor Productivity (TFP) is positively shocked to simulate an increase output in the milk and cattle sector[11] due to the cloning techniques.

In milk production, cloning has the potential to increase the milk output per cow over time by increasing the spread of desired genetic characteristics. The yearly improvement of yield could be as big as 300kg of milk per cow (Dematawewa and Berger 1998). Butler and Wolf (2010) use this increase to estimate the percentage increase in output through a ten-year time period and calculate the net present value of adopting the cloning technique in the US dairy farms. In their analysis the authors account for the fact that the switch to cloning will not happen at once. Farmers will incorporate the novel cows in their normal herd replacing regime. The slow speed adoption results in a delayed benefit creation of the technology. Moreover they assume a price premium of USD 50 to USD 200 for a cloned animal and the need for increased input use. Combining the increased output with the increased input costs, they conclude that the average annualized Net Present Value (NPV) for one cow is around USD 5 dollar. This increase in NPV can be translated in an increase in TFP through a comparison with the input costs of milk in the US, which are around USD 23/cwt or EUR 0.52/L milk (USDA). This leads to an estimated increase of TFP of 0.35% for the US dairy sector.

As no further information is available for the other countries, a similar increase in TFP is assumed for the other regions commercially applying the cloning technique in Scenario 1.

Moreover, as no information is available for the effect of cloning on the cattle sector, we assume that the effect on TFP has the same magnitude as in the milk sector.

5.3. Scenario 2

Scenario 2 is not modelled in this version of the report. The results will be similar to scenario 1 and 4 as it is a combination of both scenarios.

5.4. Scenario 3 – Cloning forbidden in the EU

The cloning technique is forbidden in the EU. The cloning technique is available in third countries which signed the joint statement on animal cloning for livestock production (Argentina, Brazil, New Zealand and the US).

[11] We highlight again that in this study the cattle and beef product categories are an aggregate of beef, goat, horse and sheep and respectively their meat as these commodities cannot be disentangled in the model. Where this assumption might influence the results the analysis is deepened based on secondary data sources.

MODEL: An increase in productivity of cattle and milk production stemming from the use of the cloning technique is assumed. The TFP is positively shocked to simulate increased output in the milk and cattle sector for the selected countries. The magnitude of the shock is equal to the assumption tailored for Scenario 1.

5.5. Scenario 4 – Cloning forbidden in the EU and traceability for imports

The cloning technique is forbidden in the EU. The cloning technique is available in third countries which signed the joint statement on animal cloning for livestock production (Argentina, Brazil, New Zealand and the US).

MODEL: An increase in productivity of cattle and milk production stemming from the use of the cloning technique is assumed. The TFP is positively shocked to simulate an increase output in the milk and cattle sector in the selected countries. The magnitude of the shock is equal to the assumption tailored for Scenario 1.

A mandatory traceability and labelling system for food coming from offspring of cloned animals is established.

MODEL: Traceability requirements for food coming from offspring of cloned animals lead to a direct increase in production cost both at the farm level and further down the supply chain. Costs contain among others:

- Tags
- Increased labour use
- Possible animal injury
- Reading costs
- Software costs

However, several countries which signed the joint statement on animal cloning for livestock production already have a traceability system in place to increase market access and secure food and animal safety. We assume the existing traceability system can be used to trace clones and their offspring without inducing extra costs. This assumption is conditional on the specification of the traceability system put in place. One of the possible extra costs we did not account for is the establishment of a DNA-register as a control mechanism. The need for such a system will increase costs even for those countries already having a traceability system. Only in the US, where no traceability system exists, a novel system for cloning has to be setup leading to increased production costs. The magnitude of the cost increase has been estimated by APHIS (2009). According to their estimates, the costs would amount to USD 139 764 000 for the US cattle sector, while for the milk sector the costs are as high as USD 32 769 000. In order to translate these values to model inputs we compare the cost increase to the total value of production (USDA) (0.4% for cattle and 0.9% for milk).

In a similar way we increase the cost of services with USD 66 027 000 in the production of food (dairy and beef) from cloned animals to take into account the increased cost of labelling and traceability (APHIS, 2009).

It has to be noted that the model does assume there is a demand for labelled products in the EU. If not the labelling requirement might result in a suspension of trade from the regions using cloning.

5.6. **Scenario 5 – EU Import ban**

The cloning technique is forbidden in the EU. The cloning technique is available in third countries which signed the joint statement on animal cloning for livestock production (Argentina, Brazil, New Zealand and the US).

MODEL: An increase in productivity of cattle and milk production stemming the use of the cloning technique is assumed. The TFP is positively shocked to simulate an increase output in the milk and cattle sector due to the cloning techniques. The magnitude of the shock is equal to the assumption tailored for Scenario 1.

Import ban on live animals, reproductive materials and food from clones and offspring coming from cloning countries (Argentina, Brazil, New Zealand and the US). This ban can be due to express prohibition or a de facto *decision by the exporters.*

MODEL: Ban of the EU imports of live animals and beef produced in countries allowing cloning by increasing import tariffs up to an almost prohibitive tax that would impede the imports. Banned countries can export their products to other countries but no re-exportation from these countries to the EU is allowed. Possibilities for the EU to cope with the shortages following the import ban include increasing domestic production or imports from third partners. However, only countries which already have a health certificate will be allowed to export meat to the EU.

6. GLOBE simulation results

6.1. Imports

Table 5 presents the effect of the different simulated policy scenarios on the composite import of cattle, milk, beef and dairy in the EU 27. In general the results show only marginal changes in the imports under the assumptions of scenario 1, 3 and 4. This indicates that the productivity increase from cloning is not significant enough to change trade patterns. Imports of beef and dairy slightly increase when the EU decides not to use cloning but allowing the imports stemming from cloning (Scenario 3). At the same time, the cost of setting up traceability systems in the US (Scenario 4) marginally reduces the imports of primary products (milk and beef) compared to the baseline. In these three scenarios (1,3,4), price effects are negligible.

More important changes are observed under the assumptions of scenario 5 which introduces a ban on the imports into the EU of cattle, milk, beef and dairy produced from countries expected to use the cloning technique (US, New Zealand, Brazil and Argentina). The ban mainly affects the cattle imports which drop over 50% and beef imports with a decrease of almost 60%. At the same time, the reduced possibilities to import translate into an increase of the import prices of these commodities by approximately 10%. The general trends are similar in the dairy market but the magnitude of the impacts are smaller with a decrease of about 20% in imports of dairy leading to a price increase for imports of 1%.

The decrease imports depicted in Table 5 is a net effect. The reduced availability from imports from those countries using cloning is compensated by an increase of imports from other exporting regions. This shift is shown in Table 6. Canada and Australia increase imports to the EU of cattle (7%) and beef (12%). A further increase in imports from these countries is not only constrained by the available inputs but also by the trade agreements with these countries. The EU could combine its ban on imports from the specified countries with an increase of TRQs for other countries. The model shows[12] that doubling the TRQs for Uruguay and Australia would slightly decrease the pressure on import volumes and prices leading to a fall in beef import of only 48% compared to 58% without the change in TRQs. However, no information is available on combined policy changes and therefore that option is not considered in detail in the remainder of this study.

The analysis of the effect of scenario 5 on the imports of cattle, beef, milk and dairy seems to suggest that either demand for these products or domestic production will have to change in order to balance the EU market. Therefore the next section focuses on the EU production changes under the different scenarios.

[12] For sake of simplicity the results of this additional scenario (Scenario 5 plus additional TRQs for Uruguay and Australia) are not reported in the report but are available upon request from the authors.

Table 5: EU imports (values in million USD and prices and quantities in percentage change)

	Baseline	Scenario 1			Scenario 3			Scenario 4			Scenario 5		
	Value	Value	Quantities	Prices	Value	Quantities	Prices	Value	Quantities	Prices	Value	Quantities	Prices
Cattle	508	508	-0,02%	-0,11%	508	0,06%	-0,01%	507	-0,06%	0,01%	249	-50,98%	9,51%
Milk	181	181	-0,20%	-0,09%	181	0,00%	-0,01%	181	-0,01%	0,01%	181	-0,03%	0,41%
Beef	3852	3853	0,04%	-0,04%	3855	0,08%	-0,01%	3854	0,07%	-0,01%	1584	-58,87%	10,49%
Dairy	2855	2855	0,00%	-0,05%	2857	0,07%	0,00%	2856	0,05%	0,00%	2270	-20,47%	1,22%

Table 6: EU imports (bilateral flows from selected countries and products) million USD and quantities in percentage change

		Baseline	Scenario 1		Scenario 3		Scenario 4		Scenario 5	
		Value	Value	Quantities	Value	Quantities	Value	Quantities	Value	Quantities
US	Cattle	272	273	0,03%	273	0,10%	272	-0,12%	6	-97,70%
	Milk	0	0	-0,19%	0	0,00%	0	-0,01%	0	-100,00%
	Beef	169	169	0,02%	169	0,08%	169	-0,10%	2	-98,53%
	Dairy	123	123	0,00%	123	0,08%	123	-0,33%	4	-96,74%
Brazil	Cattle	1	1	0,01%	1	0,00%	1	-0,01%	0	-100,00%
	Milk	1	1	0,17%	1	0,38%	1	0,34%	0	-100,00%
	Beef	517	518	0,07%	518	0,13%	518	0,12%	15	-97,07%
	Dairy	6	6	0,02%	6	0,01%	6	0,00%	0	-100,00%
Argentina	Cattle	6	6	0,25%	6	0,34%	6	0,33%	0	-97,89%
	Milk	0	0	-0,19%	0	0,00%	0	-0,01%	0	-100,00%
	Beef	583	583	0,00%	583	0,00%	583	0,00%	15	-97,35%
	Dairy	6	6	0,02%	6	0,01%	6	0,00%	0	-100,00%
Uruguay	Cattle	1	1	0,01%	1	0,00%	1	-0,01%	1	-3,76%
	Milk	0	0	-0,19%	0	0,00%	0	-0,01%	0	-0,14%
	Beef	403	403	0,00%	403	0,00%	403	0,00%	403	0,00%
	Dairy	1	1	0,02%	1	0,01%	1	0,00%	1	-1,77%
Canada	Cattle	20	20	-0,09%	20	0,00%	20	0,00%	22	7,46%
	Milk	0	0	-0,19%	0	0,00%	0	-0,01%	0	-0,14%
	Beef	41	41	-0,06%	41	0,00%	41	-0,01%	46	12,20%
	Dairy	36	36	-0,06%	36	0,01%	36	-0,02%	36	1,42%
Australia	Cattle	5	5	-0,09%	5	0,00%	5	0,01%	5	7,96%
	Milk	0	0	-0,19%	0	0,00%	0	-0,01%	0	-0,14%
	Beef*	253	252	-0,06%	253	0,00%	253	-0,01%	283	12,23%
	Dairy	62	62	-0,07%	62	0,00%	62	0,00%	63	1,42%
New Zealand	Cattle	2	2	0,01%	2	0,00%	2	-0,01%	0	-100,00%
	Milk	0	0	0,24%	0	0,46%	0	0,44%	0	-100,00%
	Beef*	1186	1187	0,13%	1188	0,20%	1188	0,19%	42	-96,47%
	Dairy	484	486	0,32%	486	0,40%	486	0,40%	1	-99,72%

* The beef commodity contains an important part of sheep meat. For New Zealand sheep and goat meat amounts to 82% of the total traded.

6.2. **Production changes**

Table 7 presents the changes in the EU's domestic production under the different scenarios.

In scenario 1, the EU captures the productivity increase from the cloning technique, increasing the competitiveness of the cattle/beef and milk/dairy sector vis-à-vis the other agricultural sectors. This leads to a small increase in domestic production combined with a slight decrease in the producer price.

Under scenario 3 and 4, no significant changes compared with the baseline are observed. This is expected as the changes in imports were marginal under these scenarios and the competitive position of different sectors in the EU remains stable as the cloning technique cannot be used by EU farmers.

Under scenario 5, a ban of imports from countries allowing the technique of cloning, the effects are more pronounced. As imports decrease significantly, EU domestic production increases in order to match domestic demand. However, percentage changes in production are small as the volume traded is little compared to production, especially in the milk/dairy sector.

The production of cattle increases by 4% and the production of beef by 6%. This represents a significant increase in output value estimated at USD 4.28 billion. The increased production has spill over effects on other agricultural sectors. The demand for fodder increases by 4%. This increased demand leads to a higher demand for land increasing the land price by 1.35%. The increased price for both land and fodder leads to producer price increase in beef sector (0.30%) and in other sectors such as cereals, grains and other crops of about 0.1%. As the share of imports and the effect on imports under scenario 5 is smaller in the milk/dairy sector, changes are marginal with a production increase of about 0.5% and a price increase of around 0.1%.

As indicated before, the model cannot differentiate between beef, sheep, goat and horse meat. Instead, the model relies on an aggregated commodity, which does not permit a further disaggregation of the specific effects in the beef or the sheep meat market.

However, EU trade and production data can be used to interpret the aforementioned model results. First, total imports of beef, sheep and goat meat represent 7% of the EU domestic production, expressed in physical volume (Eurostat). This is consistent with the increase of production forecasted by the model in case of an import ban. Looking more into the details, the situation is very different for the different meat products. Whereas imports of beef meat represent less than 5% of the EU domestic production, for sheep and goat the figure climbs to more than 30%. Banning the imports of sheep and goat meat – most of them coming from New-Zealand – would thus represent a bigger challenge to the EU sector than the results of the model suggest especially if this availability gap has to be filled through domestic production. The same situation depicted for volume of meat products also apply for prices. The producer price change foreseen by the model might also hide an important differentiation between products. Imposing a ban will likely result in a much higher producer price increase for sheep meat than for beef meat, even if some substitution might occur. The model results present a rather small price change as it is mainly driven by the beef market. A more detailed analysis of these markets will be required in case cloning in sheep and goat meat proves to be of importance.

Table 8 presents the effect of the different policy scenarios on selected trade partners. Under scenario 1 and 3 those countries that do not have access to the cloning technique (Uruguay, Canada and Australia) experience a slight production reduction in the commodities under research while cloning countries experience a slight increase due to the increased TFP.

Under scenario 4 a reduction in the production in the US is showed due to the cost of the traceability system to be put in place. The fact that the US does not reap the benefits of cloning causes that countries not adopting cloning technique slightly increase their output (mainly Canada).

Assuming a ban in scenario 5, a diverse range of impacts on domestic production can be observed. The importance of these effects is determined by the ratio of exports to domestic production. For large producers such as the US and Brazil, the loss of the EU market is not important percentagewise. For the Argentinean beef and cattle sector the impact is of a higher magnitude, with the model suggesting a 6% decrease in production. For New Zealand the ban could result in a significant production loss up to 17% for beef production as they depend to a large extent on exports, and particularly on those entering the EU. As New Zealand is mainly exporting sheep meat, this loss will be predominantly attributed to the sheep sector.

Table 7: Production in the European Union (value in USD million and quantities and producer prices in percentage change)

	Baseline	Scenario 1			Scenario 3			Scenario 4			Scenario 5		
		Value	Quantities	Prices	Value	Quantities	Prices	Value	Quantities	Prices	Value	Quantities	Prices
Cattle	45473	45483	0,02%	-0,11%	45470	-0,01%	0,00%	45472	0,00%	0,00%	47481	4,42%	0,07%
Milk	73842	73868	0,04%	-0,21%	73840	0,00%	0,00%	73842	0,00%	0,00%	74116	0,37%	0,13%
Beef	70040	70053	0,02%	-0,04%	70036	-0,01%	0,00%	70036	-0,01%	0,00%	74315	6,10%	0,30%
Dairy	345024	345115	0,03%	-0,05%	345010	0,00%	0,00%	345020	0,00%	0,00%	346501	0,43%	0,07%

Table 8: Production in selected countries (value in USD million and quantities in percentage change)

		Baseline	Scenario 1		Scenario 3		Scenario 4		Scenario 5	
		Value	Value	Quantities	Value	Quantities	Value	Quantities	Value	Quantities
US	Cattle	45883	45897	0,03%	45898	0,03%	45862	-0,04%	45689	-0,42%
	Milk	41773	41781	0,02%	41782	0,02%	41747	-0,06%	41747	-0,06%
	Beef	116862	116883	0,02%	116883	0,02%	116834	-0,02%	116691	-0,15%
	Dairy	112359	112372	0,01%	112374	0,01%	112275	-0,08%	112273	-0,08%
Brazil	Cattle	19036	19054	0,10%	19054	0,10%	19054	0,10%	18980	-0,29%
	Milk	11258	11271	0,11%	11271	0,11%	11271	0,11%	11269	0,10%
	Beef	33158	33185	0,08%	33185	0,08%	33185	0,08%	33032	-0,38%
	Dairy	21670	21684	0,07%	21685	0,07%	21685	0,07%	21679	0,04%
Argentina	Cattle	3927	3936	0,21%	3936	0,21%	3936	0,21%	3688	-6,09%
	Milk	1997	2000	0,15%	2000	0,16%	2000	0,17%	2002	0,25%
	Beef	7493	7504	0,15%	7504	0,15%	7504	0,15%	7062	-5,75%
	Dairy	5844	5851	0,12%	5851	0,13%	5852	0,13%	5852	0,13%
Uruguay	Cattle	1391	1391	-0,02%	1391	-0,02%	1391	0,00%	1390	-0,11%
	Milk	361	361	-0,03%	361	-0,02%	361	-0,01%	361	-0,15%
	Beef	1901	1901	-0,03%	1901	-0,03%	1901	0,00%	1899	-0,13%
	Dairy	968	968	-0,03%	968	-0,03%	968	-0,01%	966	-0,17%
Canada	Cattle	5396	5394	-0,03%	5394	-0,03%	5397	0,03%	5389	-0,13%
	Milk	5583	5583	-0,01%	5583	-0,01%	5583	0,00%	5581	-0,04%
	Beef	17690	17688	-0,01%	17688	-0,01%	17691	0,01%	17696	0,03%
	Dairy	15547	15546	-0,01%	15547	-0,01%	15548	0,00%	15541	-0,04%
Australia	Cattle	8546	8545	-0,01%	8545	-0,01%	8546	0,00%	8555	0,10%
	Milk	4441	4440	-0,02%	4440	-0,02%	4440	-0,01%	4435	-0,12%
	Beef	13965	13964	-0,01%	13964	-0,01%	13966	0,00%	13983	0,13%
	Dairy	10625	10623	-0,02%	10623	-0,02%	10624	-0,01%	10611	-0,14%
New Zealand	Cattle	3393	3397	0,12%	3397	0,13%	3398	0,15%	2957	-12,84%
	Milk	8131	8154	0,27%	8155	0,28%	8156	0,31%	7965	-2,05%
	Beef	5864	5870	0,11%	5871	0,13%	5872	0,15%	4857	-17,18%
	Dairy	10381	10411	0,29%	10413	0,30%	10415	0,33%	10240	-1,37%

6.3. **Exports from the EU**

As a whole the EU export of the commodities under research is rather limited, with the exception of dairy products which account for around USD 12 billion annually. Hence not drastic changes are expected under all scenarios.

Under scenario 1, with cloning available, the EU would be able to slightly increase exports, mainly to those countries that would not adopt cloning. Following the increased availability of products on the world market, prices slightly decrease (**Table 9**).

When assuming the EU does not permit the use of cloning (Scenario 3) the export of the EU contracts as it competes with countries benefitting from the productivity increase from cloning. However, when traceability is required, only negligible effects can be observed in the EU exports.

Under scenario 5, the export from the EU to other countries reduces slightly as the world market is saturated by countries that cannot export to Europe anymore and the fact that imports have decreased making the domestic market attractive.

6.4. **The EU Domestic Market**

When all countries, including the EU, have access to the cloning technique the increased productivity in the cattle and milk sector leads to slightly lower prices on the European market with the biggest price decreased observed in the milk market, 0.2% (**Table 10**). In scenario 3 and 4, where the EU does not have access to the cloning technique prices remain stable compared to the baseline. The marginal change in imports is too small to change the price on the domestic market, moreover because the total share of imports in the sectors under research is limited.

Again the effects are most pronounced in the case the EU would ban the imports from countries using cloning (Scenario 5). Total consumption of cattle and beef drops by 0.7% and 1.2% respectively. This reduced availability leads to a higher price for consumers for both products. However, the price effect is the outcome of two opposed forces. A downwards push on the price comes from the increased internal production which increases domestic supply. On the other hand, an upwards push comes from the decrease in imports and the price increase of imported goods. In the cattle market this impact remains small, 0.7%, but in the beef market this leads to a price increase of 2.4% for European consumers. As the model cannot differentiate between beef, goat, horse and sheep products, it might well be possible that price changes in specific markets are even higher. For instance in the sheep meat market, where the effect of banning imports from New Zealand might contract the market to such an extent that the domestic production cannot adequately fill the gap, prices rise could be higher. The other meat products finally, mainly poultry and pork, experience a slight price increase (0.07%) due to the increased input prices and small increase in demand due to substation from beef.

The change in prices, production and trade can be summarized by a change in welfare. In CGE models welfare effects are calculated as an equivalent variation, the amount that would lower utility by the same amount as the change in competitiveness observed in the simulation. For the EU households the price increases in the agricultural sector lead to a welfare loss of about USD 1.7 billion, or approximately USD 3.4 for each of the 500 million citizens in the EU 27.

Table 9: EU exports (value in USD million and quantities and prices in percentage change)

	Baseline	Scenario 1			Scenario 3			Scenario 4			Scenario 5		
		Value	Quantities	Prices	Value	Quantities	Prices	Value	Quantities	Prices	Value	Quantities	Prices
Cattle	1407	1408	0.07%	-0.08%	1406	-0.03%	-0.02%	1407	0.01%	0.01%	1414	0.52%	-0.61%
Milk	7	7	0.29%	-0.10%	7	-0.02%	-0.01%	7	0.06%	0.02%	7	-0.17%	-0.02%
Beef	1915	1916	0.05%	-0.03%	1914	-0.03%	-0.01%	1914	-0.02%	0.00%	1905	-0.51%	-0.19%
Dairy	12833	12839	0.04%	-0.05%	12828	-0.04%	-0.01%	12833	0.00%	0.00%	12782	-0.40%	-0.06%

Table 10: Consumption in the EU (value in USD billion and quantities and consumer prices in percentage change)

	Baseline	Scenario 1			Scenario 3			Scenario 4			Scenario 5		
		Value	Quantities	Prices	Value	Quantities	Prices	0.38	Quantities	Prices	Value	Quantities	Prices
Cattle	0.38	0.38	0.10%	-0.11%	0.38	0.00%	0,00%	2.66	0.00%	0,00%	0.37	-0.67%	0.73%
Milk	2.66	2.67	0.19%	-0.21%	2.66	0.00%	0,00%	56.12	0.00%	0,00%	2.66	-0.14%	0.13%
Beef	56.12	56.13	0.02%	-0.04%	56.12	0.00%	0,00%	147.73	0.00%	0,00%	55.44	-1.20%	2.37%
Other meat	147.73	147.75	0.01%	-0.01%	147.73	0.00%	0,00%	164.08	0.00%	0,00%	147.66	-0.05%	0.07%
Dairy	164.08	164.13	0.03%	-0.05%	164.08	0.00%	0,00%	345,03	0.00%	0,00%	163.91	-0.11%	0.18%

7. How to interpret modelling results

The model used in this study is designed as a tool to compare different policy options. First a reference scenario or baseline is simulated and then, after changing the policy settings, a new scenario is run. Comparison of the new scenario with the baseline at a given point in the simulation period, usually in terms of *percentage differences*, establishes the direction and relative magnitude of the impact of the policy shock on all the endogenous variables at that point in time. In other words, this model is intended to allow comparisons for the same moment in time (i.e. holding time constant) between the outcomes prevailing in several different hypothetical "states of the world". In the context of this study, the time period of interest is the year 2020, and the alternative states of the world correspond to different hypothetical policy options on cloning technique in the EU and trade patterns with selected countries assumed to adopt the cloning technique.

From the above considerations we conclude that the model should not be used as a tool to predict individual values of particular variables. However, the model is reliable in simulating the impact of a particular policy change in 2020, relative to the baseline situation, since the influences of any imperfections in the model and of unforeseen exogenous shocks are likely to be cancelled out across the two scenarios being compared, leaving a deviation between the two that has a lower component of error.

Although this type of model is calibrated so as to fit a given historic base year very closely, its projections become less reliable the further into the future it is used to simulate outcomes. Given the very large number of assumptions, estimated or calibrated parameters, and stylised specification features that these models assemble, each of which is 'correct' only up to an (unknown) probability, it is impossible to establish confidence intervals or margins of error around individual projected numbers. For this reason, users should be cautious about making elaborate interpretations of rather small changes, or rejecting overall model outcomes because a few details of a relatively minor order of magnitude appear counter-intuitive. Such results may simply be due to 'noise' in the model, and could well be revealed as not significantly different from zero if only their true probability distribution (given the large 'probabilistic' content of the model) could be calculated.

8. Conclusions

The analysis attempts to quantify the effect of the use of animal cloning techniques within the dairy and beef chain under a set of different EU policy options as proposed by the European Commission in the 2012 Roadmap entitled "Measures on animal cloning for food production in the EU". The analysis focusses on the impact of the technique and its associated EU policies on trade patterns, production levels and the EU domestic market.

In a first scenario (scenario 1) it is assumed that the cloning technique is available and will be used in the EU and in third countries which signed the joint statement on animal cloning for livestock production (Argentina, Brazil, New Zealand and the US). The analysis shows that this scenario would only have a limited effect in the beef and dairy sector. Although the use of cloning increases productivity and hence the competitiveness of the livestock sector vis-à-vis other sectors, the application in major trade partners limits the effects on trade as relative competitiveness is hardly affected.

In a next scenario (scenario 3) it is assumed that the EU would ban the use of the cloning technique on its territory but allow imports from countries that use the technology. Therefore, the selected trade partners using the technique of cloning would increase their relative competitiveness towards the EU leading to increased EU imports. However, as the productivity improvement that the cloning technique is expected to bring before 2020 is considered small, the change in the EU trade balance is marginal. The increased imports of cattle, beef and dairy have in turn a negligible effect on EU domestic prices and production as imports only represent a small part of domestic use.

When traceability and labelling are added as a requirement for imports from countries using the cloning technology (as in scenario 4), overall EU imports are almost unaltered compared to the baseline but slightly down. The bilateral trade flows indicate that the imports from countries using the technique of cloning decrease. This is because the cost of implementing traceability and labelling systems offsets the benefits of the productivity increase from the application of cloning. Again the changes are too small to lead to significant production or price effects in the EU's domestic market.

In a final scenario (scenario 5), it is assumed that EU imports of cattle, beef, milk and dairy come to a halt for those countries using the technique of animal cloning. The assumed trade disruption could be a direct result from a (temporary) ban by the EU on all imports of products derived from cloned animals or their offspring. However, it could also stem from a *de facto* decision by exporters not to export to the EU because of the associated high regulatory costs. As demonstrated in a former scenario the costs of traceability and labelling requirements might outweigh the benefits of exporting to the EU for some trade partners. This is especially the case when other export markets exist that do not require similar systems (e.g. Asian markets).

The analysis shows that when imports from Brazil, US, Argentina and New Zealand are suspended due to their use of the cloning technique, the gap in EU demand is filled by both increased domestic production and diversified sources of imports. EU cattle production is expected to grow about 4% while the beef sector grows slightly more with 6%. Although the percentage changes are rather small the value of this expanded domestic production is significant representing about USD 4.28 billion. The production expansion is combined with a slight increase in producer prices. A similar chain of events is expected for the milk and dairy sector. However, as the share of imports in total production is smaller, the effect on domestic production and prices are less pronounced.

New import sources include Canada and Australia which significantly increase their exports to the EU taking full advantage of their non-use of the animal cloning technique under this scenario.

However, the import substitution effect in the EU is not complete. Total EU imports decrease significantly, by 50 % in case of cattle and beef and by 20% for dairy imports. This leads to an increase in imports prices. For cattle and beef, import prices would rise by about 10% while the price increase for dairy is only about 1%.

The relative tightness on the EU market and the increased domestic production have an impact on the wider agricultural system. The production expansion in the EU affects the upstream supply chain through an increased demand in feed and fodder of approximately 4%. This increased demand leads to small price increases for all other land based production systems such as cereals. European consumers at the other end of the supply chain would experience a slight price increase as the increase in domestic production does not fully compensate for the decrease in imports. The effect on consumer prices is most pronounced for beef where it amounts to about 2%. For cattle, milk and dairy the price effects are considerably smaller, not surpassing 1%. The price of other meat products, mainly poultry and pork, increases marginally through a combined effect of consumer substitution and price increases in their input markets.

The combined impact of the allocation, trade and price changes can be economically estimated by the change in total welfare. The analysis suggests that in the case where EU imports of cattle, beef, milk and dairy from those countries using the technique of cloning are halted due to a ban or a de facto interruption of trade, the EU would face a welfare loss of USD 1.7 billion.

A general caveat to the results is that the price and production effects could well be higher in specific small or niche markets. The reason is twofold. First of all, the model cannot differentiate between beef, goat, sheep and horse meat which in reality are differentiated markets. For example, imports from New Zealand represent about 80% of the EU's total imports of sheep meat. If these imports were halted, EU domestic production would not be able to fulfil demand, leading to price effects for specific sheep meat products that could be higher than depicted in this study. Secondly even within one commodity, goods are not necessarily considered homogeneous by the consumer. In some high value niche markets such as marbled beef, a trade distortion could increase prices sharply. These specific situations should be further investigated in order to fully understand the economic effects of a trade ban for the EU.

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10. Annexes: Model specification and details of scenarios

Annex 1: Model specification and details of scenarios

Table A 1: Sector aggregation in GLOBE

No	Code	Description of product category	HS code
1	cer	Rice and Wheat	1006 rice 1001 Wheat and meslin
2	gro	Cereal grains nec	1002 rye in the grain 1003 barley 1004 oats 1005 corn (maize) 1007 grain sorghum 1008 buckwheat. millet & canary seed. cereals nesoi
3	othc	Other crops	0199 Other raw vegetable materials 0296 raw animal materials used in textiles 06 Live trees. other plants. cut flowers 07 edible vegetables 08 ed. fruits & nuts. peel of citrus/melons 12 oil seeds/misc. grains/med. plants/straw 13 lac. natural gums. resins. etc. 14 vegetable plaiting materials 50 silk. inc. yarns & woven fabrics thereof 51 wool & fine or coarse animal hair. inc. yarns & woven fabrics thereof
4	ctl	Live cattle. sheep. goats. horses	0101 horses. Asses. mules and hinnies. live 0102 bovine animals. live 0104 sheep and goats. live
5	oap	Live pigs. poultry. other unprocessed or preserved animal products	0103 swine. Live 0105 chickens. ducks. geese. turkeys. and guineas. live 0106 animals. live. nesoi - not elsewhere specified of indicated. 0407 birds' eggs. in the shell. fresh. preserved or cooked 0408 birds' eggs. not in shell & yolks. fresh. dry. etc 0409 honey. natural 0410 edible products of animal origin. nesoi 05 products of animal origin
6	rmlk	Raw milk	0401 milk and cream. not concentrated or sweetened
7	prim	Primary Sectors: fish, forestry and mining	03 fish & crustaceans 25 salt. sulphur. earth & stone. lime & cement 26 ores slag & ash 27 mineral fuels, oils, waxes & bituminous sub 44 wood & articles of wood. wood charcoal 45 cork & articles of cork 46 manu. Of straw. esparto. or other plaiting materials. basketware and wickerwork 47 pulp of wood. waste & scrap of paper
8	cmt	Meat cattle, sheep, goat, horses	0201 meat of bovine animals. fresh or chilled 0202 meat of bovine animals. frozen 0204 meat of sheep or goats. fresh. chilled or frozen 0205 meat of horses. asses. mules. hinnies fr. chld. fz 0206 edible offal. bovine. swine. sheep. goat. horse. etc.
9	omt	Meat pork, poultry, other	0203 meat of swine (pork). fresh. chilled or frozen 0207 meat & ed offal of poultry. fresh. chill or frozen 0208 meat & edible offal nesoi. fresh. chilled or frozen 0209 pig & poultry fat fresh chld frzn salted dried smkd 0210 meat & ed offal salted. dried etc. & flour & meal
10	dair	Dairy products	0402 milk and cream. concentrated or sweetened 0403 buttermilk. yogurt. kephir etc. flavored etc or not 0404 whey & milk products nesoi. flavored etc. or not 0405 butter and other fats and oils derived from milk 0406 cheese and curd
11	ofod	Food products nec	16 ed. prep. of meat. fish. crustaceans. etc 19 preps. of cereals. flour. starch or milk 20 preps of vegs. fruits. nuts. etc. 21 misc. edible preparations 23 residues from food industries. animal feed
12	food	Processed rice, sugar, Beverages and tobacco	09 coffee. tea. mate & spices 11 milling industry products 15 animal or vegetable fats. oils & waxes 17 sugar (raw. refined. confectionery) 18 cocoa & cocoa preparations 22 beverages. spirits & vinegar 24 tobacco & manuf. Tobacco substitutes

13	manufs	Manufactures and machinery	28 inorganic chem. org/inorg compounds of precious metals. isotopes 29 organic chemicals 30 pharmaceutical products 31 fertilizers 32 tanning or dyeing extracts. dyes. pigments. paints & varnishes. putty. & inks 33 oils & resinoids. perfumery. cosmetic or toilet preparations 34 soaps. waxes. scouring products. candles. modeling pastes. dental waxes 35 albuminoidal sub. starches. glues. enzymes 36 explosives. matches. pyrotechnic products 37 photographic or cinematographic goods 38 miscellaneous chemical products 39 plastics & articles thereof 40 rubbers & articles thereof 41 raw hides & skins & leather 42 articles of leather. saddlery & harness. travel goods. handbags. articles of gut 43 furskins & artificial fur. manufactures 48 paper & paperboard. articles of paper pulp 49 printed books. newspapers. pictures. manuscripts. typescripts & plans 52 cotton. inc. yarns & woven fabrics thereof 53 veg. textile fibers nesoi. yarns & woven etc. 54 man-made filaments. inc. yrns & woven etc. 55 man-made staple fibers. inc. Yarns etc. 56 wadding. felt & nonwovens. special yarns. twine. cordage. ropes & cables & articles 57 carpets & other textile floor coverings 58 special woven fabrics. tufted textiles. lace 59 impregnated. coated. covered. or laminated textile prod. textile prod for industrial use 60 knitted or crocheted fabrics 61 articles of apparel & clothing accessories-knitted or crocheted 62 articles of apparel & clothing accessories-not knitted or crocheted 63 made-up textile articles nesoi. needlecraft sets. worn 64 footwear. gaiters. & the likeclothing. rags 65 headgear & other parts 66 umbrellas. sun umbrellas. walking-sticks. whips. riding-crops & parts 67 prepared feathers. human hair & articles thereof. artificial flowers 68 articles of stone. plaster. cement. asbestos. mica or similar materials 69 ceramic products 70 glass & glassware 71 pearls. stones. prec. Metals. imitation jewellery. coins 72 iron & steel 73 articles of iron or steel 74 copper & articles thereof 75 nickel & articles thereof 76 aluminium & articles thereof 78 lead & articles thereof 79 zinc & articles thereof 80 tin & articles thereof 81 base metals nesoi. cermets. articles etc. 82 tools. spoons & forks of base metal 83 miscellaneous articles of base metal 84 nuclear reactors. boilers. machinery & mechanical appliances. computers 85 electrical machinery & equip. & parts. telecommunications equip.. sound recorders. television recorders 86 railway or tramway locomotives. rolling stock. track fixtures & fittings. signals 87 vehicles other than railway or tramway rolling stock 88 aircraft. spacecraft. & parts thereof 89 ships. boats. & floating structures 90 optical. photographic. cinematographic. measuring. checking. precision. medical or surgical instruments & accessories 91 clocks & watches & parts thereof 92 musical instruments. parts & accessories 93 arms & ammunition. parts & accessories 94 furniture. bedding. cushions. lamps & lighting fittings nesoi. illuminated signs. nameplates & the like. prefabricated buildings 95 toys. games & sports equip. parts & acces. 96 miscellaneous manufactured articles 97 works of art. collectors' pieces. antiques

14	trade	Trade and transportation	9832 local trucking. without storage 9833 trucking. except local 9834 local trucking with storage 9835 courier services. except by air 9841 deep sea foreign freight transportation of freight 9842 deep sea domestic freight transportation of freight 9843 deep sea passenger transportation ; 9844 ferries 9845 marine cargo handling 9846 towing and tugboat service 9847 air transportation. scheduled 9848 air courier services 9849 air transportation. nonscheduled 9847 air transportation. scheduled 9848 air courier services 9849 air transportation. nonscheduled 9852 freight transportation arrangement. nvocc. customs brokerage 9853 rental of railroad cars/rail transport
15	serv	Services	9801 soil preparation services 9802 crop planting. cultivating and protecting 9803 crop harvesting. primarily by machine 9804 crop preparation serv for market except cotton ginning 9805 cotton ginning 9806 veterinary services for livestock 9807 veterinary services for animal specialties 9808 livestock services. except veterinary 9809 animal services. except veterinary 9810 farm labour contractors and crew leaders 9811 farm management services 9812 landscape counselling and planning 9813 general contractor 9814 industrial buildings and warehouse 9815 highway and street construction 9816 bridge. tunnel. and elevated highway 9817 water. sewer. pipeline. and communications construction 9818 heavy construction 9819 plumbing. heating and air conditioning 9820 electrical work 9821 masonry. stone setting. tile setting & plastering 9822 plastering. drywall. and insulation work 9823 tile. marble. and mosaic work 9824 carpentry 9825 roof. siding. and sheet metal work 9826 concrete work 9827 water well drilling 9828 glass and glazing work 9829 excavation work 9830 wrecking and demolition work 9831 special trade contractors 9854 packing & crating 9855 inspecting and fixed facilities 9856 electric services 9857 natural gas transmission 9858 natural gas distribution 9859 gas production and/or distribution 9860 water supply 9861 sewerage systems 9862 refuse systems 9863 sanitary services 9864 steam and air-conditioning supply 9865 irrigation systems 9866 engineering services 9867 architectural services 9868 surveying services 9869 accounting. auditing. and bookkeeping 9870 commercial physical research 9871 commercial nonphysical research 9872 noncommercial research organizations 9873 testing laboratories 9874 management services 9875 management consulting services 9876 public relations services 9877 facilities support services 9878 business development/ consulting. nesoi 9879 air. water & solid waste management services 9880 land & wildlife conservation 9881 recycling 9882 energy saving equipment 9883 environmental cleanup 9884 environmental testing services 99 Business services Public services

Table A 2: Regional aggregation in GLOBE

No.	Code	Country
1.	**EU27**	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic, Slovenia
2.	**US**	US
3.	**BRA**	Brazil
4.	**ARG**	Argentina
5.	**URY**	Uruguay
6.	**CAN**	Canada
7.	**AUS**	Australia
8.	**NZL**	New Zealand
9.	**CHIND**	China, Hong Kong, India, Thailand
10.	**OECD**	Japan, Chile, Mexico, South Korea, Israel, Turkey
11.	**RoEU**	Switzerland, Norway, Rest of Europe, Rest of EFTA, Croatia, Albania, Russian Federation, Belarus, Ukraine, Rest of Eastern Europe, Kazakhstan, Kyrgyzstan, Rest of Former Soviet Union, Armenia, Azerbaijan, Georgia
12.	**Other ACP countries**	Nigeria, Senegal, Rest of West Africa, Rest of Central Africa, Rest of South Central Africa, Ethiopia, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe, Rest of Eastern Africa, Botswana, South Africa, Rest of South African Customs, Caribbean Countries, Rest of Oceania, Cote d'Ivoire, Ghana, Kenya, Namibia
13.	**Rest of the World**	Paraguay, Peru, Ecuador, Panama, Colombia, Costa Rica, Guatemala, Nicaragua, El Salvador, Honduras, Bolivia, Venezuela, Rest of South America, Rest of Central America, Taiwan, Indonesia, Malaysia, Philippines, Singapore, Thailand, Pakistan, Sri Lanka, Egypt, Morocco, Tunisia, Rest of North Africa, Rest of East Asia, Cambodia, Laos, Myanmar, Vietnam, Bangladesh, Islamic Republic of Iran, Rest of Western Asia, Bahrain, Kuwait, Mongolia, Nepal, Oman, Qatar, Saudi Arabia, United Arab Emirates

Table A 3: Summary of the behavioural relationships in each segment of GLOBE, broken down by 'account'

	Commodities	Activities	Factors	Households	Government	Capital	Margins	Rest of World	Prices
Commodities	0	Leontief input-output coefficients	0	Stone-Geary utility functions	Varies with region (see closure rules)	Fixed shares of savings	3-stage CET functions	3-stage CET functions	Consumer commodity price
Activities	Total supply from domestic production	0	0	0	0	0	0	0	Activity prices
Factors	0	2-stage CES production functions	0	0	0	0	0	0	Factor prices
Households	0	0	Fixed shares of factor income	0	0	0	0	0	
Government	*Ad valorem* tax rates	*Ad valorem* tax rates on output and factor use	Average tax rates	Average tax rates	0	0	0	0	
Capital	0	0	Shares of factor income	0	Varies with region (see closure rules)	0	Current account 'deficit' on margins trade	Current account 'deficit'	
Margins	Fixed technical coefficients	0	0	0	0	0	0	0	
Rest of World	3-stage CES functions	0	0	0	0	0	0	0	
Prices	Producer prices Domestic & world prices for imports	Value-added Prices							

Source: McDonald *et al.* (undated, Table 3).

Table A 4: Assumptions about exogenous trends in GLOBE, 2007-2020

	GDP	Population	Capital	Exchange rate	GDP	Population	Capital
	Total change, 2007-2020, %				Average annual change, %		
EU27	16.61	3.54	3.94	-1.45	1.19	0.27	0.30
US	27.24	11.52	17.84		1.87	0.84	1.27
Brazil	70.27	10.87	119.29	8.93	4.18	0.80	6.23
Argentina	69.37	11.40	108.67	74.60	4.14	0.83	5.82
Uruguay	83.02	4.77	103.84	13.47	4.76	0.36	5.63
Canada	24.49	12.69	31.10	-8.92	1.70	0.92	2.10
Australia	43.29	19.51	80.88	-13.62	2.81	1.38	4.66
New Zealand	29.18	13.98	45.09	-3.77	1.99	1.01	2.90
China, India, Thailand	182.52	11.06	215.43	-4.49	8.32	0.81	9.24
Rest of OECD	22.09	8.13	20.19	-1.45	1.55	0.60	1.42
Rest of Europe	50.79	2.29	70.69	41.80	3.21	0.17	4.20
Other ACP countries	74.24	31.83	91.43	*	4.36	2.15	5.12
Rest of the World	50.20	7.64	71.00	*	3.18	0.57	4.21

Note to Table A1.4

The GDP, population and exchange rate assumptions come from Global Insight, and/or the OECD AGLINK/COSIMO database.
For regions with * in the exchange rate column, the closure rules specified balanced trade and endogenous exchange rates. The US exchange rate represents the reference region to which all other exchange rate is measured. When the sign of the growth rate is positive it means that one needs more local currency to buy one US dollar, the local currency is depreciating.

There are five factors in GLOBE, unskilled and skilled labour, capital, land and natural resources. In the model simulations, it is assumed that the availability of unskilled and skilled labour grow at the same rate as population (see table) and that land and natural resources are constant. The trend in capital availability is shown in the table.

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Abstract

The European Commission is currently evaluating different policy options towards the use of cloning or products derived from cloned animals in the food chain. This study presents a first attempt to quantify the likely effects of different policy scenarios on international trade and EU domestic production. In the context of the Impact Assessment process carried out by the European Commission, the JRC was requested to simulate via a modelling study the economic impacts of selected policy options.

Based on a literature review and after considering the specific objectives of this study, the choice was made to perform the analysis employing a Computable General Equilibrium (CGE) model called GLOBE and to focus on the dairy and beef sectors. Different model scenarios were constructed based on combinations of the discussed policy options such as a ban, or traceability and labelling requirements with associated productivity increases arising from the use of the cloning technique.

The results indicate that only in the case where trade with countries employing cloning techniques is suspended, is there a noticeable effect on competitiveness. This suspension could be due to express prohibitions or a de facto decision by exporters when traceability and labelling costs increase. Under this scenario, imports drop significantly which is followed by a slight increase in domestic production and prices, especially for beef and cattle.

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