Interbull: Constructing International Commensurability for Dairy Cattle Selection

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Abstract

Since the middle of the XXth century, the most productive Holstein breed has become the main product exchanged on the international market of breeding animals. The propagation of new technologies of genetic evaluations and breeding has been led by commercial needs marked by complementary logics of importing and exporting countries. This socio-historical analysis argues that the crucial issue for the international trade balance is the commensuration (or the process of making things comparable through a common metric) of national standards of genetic evaluation of marketed sires. Indeed, the product quality is constructed by its comparison and ranking with categories of similar products. While the true product quality is unknown or uncertain in genetics, the commensuration, as both a technical and a social process becomes paramount. The Interbull initiative has been driven from 1970's until now by research of a mean to objectively compare bull breeding values and motivated by the will of European importers to efficiently buy exotic (North-American) Holstein bulls and semen. The long scientific and political negotiations around the biological problem of accounting for "genotype by environment interaction" which was identified as a crucial point for the commensurability of genetic values resulted in the technical solution of the MACE model. A transnational space of commensurability has been formed within the technical infrastructure of Interbull Centre, providing comparable genetic evaluations of bulls, with MACE as a service to countries concerned by international trade of genetic material. Mechanisms of inclusion and exclusion of this technical space of commensurability have shaped those of the international genetic trade. The new technology of genomic evaluations and the market liberalization in the 2000's have destabilized the international commensuration. With a broadened and diversified community of players and with a new issue of genotype data sharing put in the center of technical and political negotiations the genomic selection showed the limits of the existing commensurability. Within this changing context the main challenge remains however the same: find out a new technical mean to take in account the key-point of the international commensurability of genetic values: biological aspect of "genotype by environment interaction". Thus, the Interbull case can help to understand mechanisms of international circulation of technologies for genetic and genomic evaluation through considering of the commensuration as a dynamic process rather than a static finality to come to. This process allows keeping the diversity of standards, to adapt and to re-adapt technical tools to the changing political, biological and technological issues.

Key words: socio-historical analysis, Interbull, genetic values, international, comparability, commensuration, commensurability

"Nous pouvons enfin parler de la contemporanéité mais la diversité du monde se recompose à chaque instant : tel est le paradoxe du jour. Il nous faut donc parler des mondes et non du monde, mais savoir que chacun d'eux est en communication avec les autres, que chacun d'eux possède au moins des images des autres – images éventuellement tronquées, déformées, faussées. […] Que le monde contemporain soit déjà unifié et toujours pluriel, que les mondes qui le constituent soient hétérogènes mais reliés, c'est ce qu'il nous faut revendiquer pour essayer de le comprendre. »[1]

Marc Augé « Pour une anthropologie des mondes contemporains », 1994

Introduction

Science and Technology Studies (STS) as a subfield of Social Sciences address questions of coproduction of knowledge and social order. Inscribed in this theoretical frame and based on sociological methods of participant observation and qualitative interview, our project aims to contribute to the analysis of the international diffusion of innovations through the example of technologies of cattle breeding evaluation in the context of the genomic "revolution" and its internationalization.

Livestock production is one of the most technology driven fields of agriculture. Since the middle of the XX century, the international propagation of new technologies for genetic evaluation and breeding has been led by commercial needs (Philipsson *et al.*, 1986) firstly for the Holstein breed as the most productive and the most internationalized of cattle breeds. For a better understanding of processes leading the international propagation of genomic selection as a "breakthrough" or a "disruptive" innovation of cattle evaluation, we decided to look into the history of the international genetic evaluation. Through the socio-historical analysis of Interbull organization, we address the issue of comparability of genetic values across countries and argue that this issue is the key-point for the international circulation of marketed genetic material and methodology of its evaluation. Indeed, estimated genetic or breeding value (EBV) of bulls is what the semen trade has been based on. It is the measure of product quality which is constructed by comparison and ranking within categories of similar products (Beckert and Musselin, 2013).

The true product quality of genetic material is very difficult to estimate while the measure of animal value is not direct but related to the future value of its offspring. The valuation process of the genetic potential combines elements of different nature: direct measurement of animals and their production, economic objectives, systems of livestock production, environmental conditions, statistical models, etc. So the issue of comparability of estimated genetic or breeding values (EBVs) turns into commensurability. We introduce this concept which was theorized by STS scholars (Espeland and Stevens, 1994; Espeland, 2013; Desrosières, 1990, 2014) to emphasize a specific form of comparability between things with qualitative characteristics through the creation of a common metric, usually by quantification. It is important to underline here the dual character, both social and technical, of the process of commensuration. The first stage is a social agreement: why and what to commensurate. And the second one is the technical implementation of quantification that could be done through measurement (weight, height, etc.), monetarization (for example, giving economic value to the housework of women by the feminist movement analysed by Espeland and Stevens (1994)) or statistical methods (cf. analysis of social statistics by Desrosières

[1] "*We can finally talk about modernity but the diversity of the world is recomposing itself at every moment: that is the paradox of the day. Thus, we should say "the worlds" instead of "the word" and keep in mind that each of them is in communication with the others, that each of them possesses at least images of the others. […] The contemporary world is unified but always pluralistic. The worlds constituting it are heterogeneous but connected. That is we must claim to understand it."* (Free translation from M. Augé, « Pour une anthropologie des mondes contemporains », 1994)

(2014)). Once quantified, things can be compared and can play in this way a societal role. Thus, in the 1950's-1960's, the development of statistical genetics allowed the quantification of estimated genetic values of animals. Then, national standards of genetic selection in developed countries have been built on the "objective" comparison and ranking (within the same breed) of evaluated bulls meant to generate a genetic trend in the cattle population at farm level as well as at country level. These quantified values were considered as perfectly commensurable within each national system. But were they internationally?

The story of Interbull

In the 1970's with the development of international Holstein breed trade, specialists of cattle breeding from European countries importing American bulls realized that EBVs expressed through numbers were not really comparable between different countries. The story of Interbull started at that moment, when European importers wanted to better assess the quality of the product they were buying from abroad.

We can define three main stages in the history of Interbull. During the first one (1975-1993), the lack of comparability of bulls' EBVs between countries was identified and the process of its construction was launched by several working groups of scientists. The second one (1993-2009) is a period of the stabilized commensurability with the MACE model and the construction of an international commensuration space around the technical infrastructure of the Interbull computing centre. The current period (from 2009 up to now) is characterized by the development of genomic selection, which has disrupted the existing international space of commensuration and put a new challenge to the broadened and more diversified Interbull community to find new solutions to keep genetic and genomic values comparable across countries.

1975-1993: Constructing commensurability

Thanks to the development of artificial insemination and cryopreservation - the "breakthrough" innovations of that moment – the trade of genetic material expanded internationally. Genetic improvement of cattle population was one of the main priorities for livestock production in the after-war Europe. The reputation of the American Holstein strain as the most productive of Black and White Friesian cattle opened the way for the "holsteinization" of the European cattle population. But specialists of cattle breeding and geneticists involved in that process in European countries were alarmed by the uncertain comparability of EBVs between imported animals and local ones and thus by the uncertainty of the imported product quality. Statistical analyses showed low correlations signifying the existence of a "genotype by environment (GxE) interaction" impacting the ranking of animals' values in different countries, i.e. the genetic merit of a given animal is different according to its own environment. These biological characteristics of live organisms have been precisely identified as the key-point of their international comparability.

Several initiatives were taken almost simultaneously by the international organizations working on different aspects of normalization and regulation of the livestock productions across countries. The Food and Agriculture Organization of the United Nations (FAO) launched in Poland a huge experimental project of comparison of ten strains of Friesian cattle (Mason *et al.,* 1975; Stolzman *et al.,* 1981; Jasiorowski *et al.,* 1987). The European Association of Animal Productions (EAAP) and the International Dairy Federation (IDF) set up working groups of researchers (mainly from Europe) with the aim to find a scientific way to compare EBVs across countries and to assess objectively the quality of the American genetic products (Philipsson, 2005, 2011). While the FAO project demonstrated that each strain of Friesian cattle had its own qualities with the undeniable superiority of the American Holstein strain for production traits, EAAP and IDF working groups collected and analysed information about different national systems of genetic evaluation and made some recommendations to harmonize methods (Gaillard *et al.,* 1977). The opening of black boxes of national evaluation standards obviously revealed that to completely

standardize all national evaluation systems was unfeasible technically as well as politically. Furthermore, to adopt one common standard of EBVs implicitly meant at that moment that it would be the American TPI™ (Total Performance Index Trademark). This was hardly acceptable in the new Europe.

The first and most evident solution to compare genetic values between countries was the conversion method. The principle of currency convertibility (Heilperin, 1954) theoretically applied to EBVs implied an application of conversion formulae calculated by the statistical method of regression without requirement of any modifications in national evaluation systems. But practically, it appeared too complicated to manage at a large international scale. Indeed, although at that moment, through international exchanges between scientists, more or less all the participating countries were converging to the use of the same statistical method for breeding evaluation – BLUP (Best Linear Unbiaised Prediction) - the conversion formulae were too many and had to be updated very often. The method allowing conversions only bilaterally, formulae were specific to each pair of countries. Furthermore, they do not properly address the existence of GxE interaction. So, with the increasing exchanges between countries it rapidly represented a huge amount of work for relatively unreliable results. Despite this complexity without any other alternative solution, the period of conversion formulae was quite long, about twelve years (Grosu *et al.*, 2013).

Meanwhile, the issue of the objective international comparability of EBVs was institutionalized and Interbull had received an official status. A space for discussions of technical as well as political nature was created with international annual meetings open to scientists and specialists of national centers of genetic evaluation. Even if the position of Interbull was officially based on technical ground with the objective to avoid as far as possible all business arguments and to maintain the scientific objectivity of the debate, the political side of the question was however transmitted by the representatives of national organizations. Thus, political debates confronted two different logics: the importing countries' one and the exporting countries' one. The issue was to decide whether to take into account the biological nature of the live product – the presence of "genotype by environment interactions". Exporters were obviously led by the logic of technical simplification whereas importers were interested to adopt a more precise methodology of evaluation which accounts for differences between countries in order to get more accurate comparisons of genetic values. From the technical side, scientists continued working on methods to treat information of all countries together (in contrast with the conversion formulae), to estimate genetic correlations between countries and using these to make EBVs produced in different geographical and political spaces comparable for the international trade, hence being more "efficient and fair" for importing countries.

The technical commensuration was constrained by the social (political) context of "coopetition" between players: a need to cooperate in order to find a common standard, to harmonize methods, but the impossibility to share strategic phenotype data because of commercial competition on the international semen market.

As mentioned earlier, the commensuration is theorized by sociologists of science and technology as both a social and a technical process. Our case of the search for commensurability of genetic values shows that the biology of marketed live animals is another crucial element to take into account when the goal is to regulate the socio-political space of international trade of animal products (Selmi and Joly 2014). Thus both the technical and political dilemmas were to make visible or invisible this biological information. From a technical point of view, it was translated into the choice of an ad-hoc model: the Multiple-Trait Across Country evaluation (MACE) model (Schaeffer *et al.*, 1993) developed in the early 1990's became a very good socio-bio-technical compromise allowing the international commensurability of genetic values (accounting for "genotype by environment interaction" through the use of genetic correlations between different countries) without a too difficult standardization of national systems and without the constraint of sharing strategic data. In other

words, the political argument around a biological issue was solved technically.

1993-2009: Performing commensurability.

The theoretically designed MACE model needed a practical implementation. Interbull had established in 1989 its own Steering Committee as a governance unit composed by scientific and technical representatives of different founder countries. It approved MACE as an optimally acceptable (scientifically and politically) technical tool. It was decided to create a computing centre and to routinely provide "commensurable" EBVs as a service to concerned countries. Thus, MACE received the status of an international standard of cattle genetic evaluation (Philipsson, 2011) which had to be performed by a normalization of procedures within a determined space (Thevenot, 1997).

The Interbull computing centre was settled in 1993 in Uppsala in Sweden, a small country in terms of its ambitions on the international market of cattle semen and from this point of view considered as "neutral" enough to provide an objective evaluation (Philipsson, 2011). The role of the "Interbull Centre" was to centralize information provided by countries, i.e. national bulls' EBVs, to recalculate their international genetic values in order to make them commensurable and to distribute them back to countries. In the process of establishment of rules collected on a Code of Practice (1994), the big debate did not take place about technical aspects of the tool but around its practical application: how many times per year and at what period to provide evaluations, etc. Indeed, even though MACE allowed the plurality of evaluation systems, countries had to agree on a set of organizational and technical rules which concerned their national breeding systems. Centralizing and operating all national information, the "Interbull Centre" rapidly became the centre of gravity of the transnational space of commensuration with a power of inclusion and exclusion.

Every created space needs to establish its boundaries. Those of the Interbull commensuration space were determined by technical capacities of member countries to prove their ability to be "commensurated" and to positively contribute to the global commensuration. First of all, as Interbull is affiliated to the International Committee of Animal Recording (ICAR), the Interbull membership requires each country to be a member of ICAR. This guarantees a good technical basis in terms of animal identification and recording as a foundation of quality of national genetic evaluation system. Within the evaluation system, one of the risks of improper statistical methods and evaluation models is the possibility to create biases which can overestimate or underestimate genetic values of some categories of bulls and advantage or on the contrary disadvantage some trade players. Biases are usually due to a technically improper modelling. To control this, test runs were set up and managed by the "Interbull Centre" to assess the technical quality of national evaluations as components of the international evaluation. Each country willing to join the Interbull community or any member country which makes changes in its national evaluation system has to pass these validation tests (Code of Practice 1994). Thus, mechanisms of inclusion and exclusion are determined technically, but they directly have a political impact. The inclusion of a country into the commensuration space means its admission into the circle of peers: the active and conscious players of the cattle genetics' market. A country excluded from the commensuration space is automatically excluded from the trade space. Even if the prejudice concerns only one evaluation run because of some technical non-conformity, it means that this country cannot sell its new bulls neither improve the ranking of its old bulls on the international market during several months. Such a decision obviously affects the breeding industry and creates tensions between national stakeholders.

Another mechanism of inclusion/exclusion is more political as it is linked to the visibility of genetic values provided by Interbull. Only the accessibility to all EBVs expressed on all country scales for all players of member countries can guarantee a good operation of the international commensurability. The normalized procedure requires an open and official publication by all participants (Code of Practice 1994). But national publication rules within each country can be in conflict with those

established by Interbull and a biased publication (for example, requiring a minimum level of EBV accuracy) can exclude some bulls and/or some players from the commercial exchanges. At this stage, a bias can be economically motivated and created intentionally to disadvantage competitors. It is generally controlled by the community members themselves especially by those penalized by this "unfair play" and a procedure of correction can be launched by Interbull. Generally, after negotiation countries accept to modify publication rules.

The performance of MACE as a service with a requirement of normativity shows how a technical tool of commensuration involves, links and consolidates together different "worlds" (Boltanski and Thevenot, 1991): the technical one, the political (or business) one and the biological one.

During this period, the circle of member countries willing to be an active part of the international space for the trade of cattle genetic material and accepted into the common commensuration process progressively grew. The Interbull community stabilized as a "club of peers" with about 30 member countries benefiting from the commensuration service provided by MACE and its infrastructure (the "Interbull Centre"). The importing as well as the exporting countries were globally satisfied by the service which allowed them to keep their own standards of national evaluation and to have a possibility to organize commercial exchanges of semen on a "fair" and mutually profitable bases.

2009-now: "Disrupted" commensurability ?

The development of methods of genomic evaluation, i.e. using information on genetic markers of the genome, is qualified by players as a "disruptive", "revolutionary" innovation allowing a large reduction of the time of the evaluation process, an acceleration of genetic progress and lower costs of the breeding programs previously based on the progeny-testing of bulls. Indeed, we observe important changes in national livestock breeding systems since the beginning of genomic selection in 2009 (Labatut *et al.,* 2014, Hannachi & Tichit, 2016). Consequently, changes in national breeding programs impacted the international organization of evaluation. Even if the new evaluation methods are not fundamentally "new" from a technical point of view as being based on the same statistical principles as before, they require an integration of a huge amount of new information – the genotype data - to be as precise as genetic evaluations of tested bulls. The new issue of access to genotypes has disrupted the balance between "peer" countries of the Interbull community and revealed more inequality between them than it was usually considered before. Face to this new technology, the gap between big and small, developed and developing countries became more visible. This inequality is both technical and economic. Big providers of genetic products with large cattle reference populations could grasp this new opportunity with an important investment of knowledge as well as technological and financial means which are required for genotyping and for technical integration of the genomic data into the new evaluation process. When these big players realized that their national populations were not large enough to achieve high accuracy, they decided to join their efforts and to create consortia to share genotypes (Cromie *et al.*, 2010). Thus, two consortia of big Holstein breed semen providers (the North-American one and Eurogenomics), plus one of smaller countries also in the Holstein breed currently under construction and the consortium of Brown Swiss breed producers illustrate a fragmentation of the international community and its concentration into several more homogeneous groups led by their distinct and sometimes competing interests. Indeed, one of the key-points for the stability/durability of a commensuration space highlighted by Ruault and Rainelli (2011) following Boltanski and Thevenot (1991) is the compromise based on a common interest (or common good) among members. When interests of players become too divergent, the compromise can fail and turn to a "private arrangement" based on a more contingent and more "local" interests.

Another constraint of the existing commensurability is the technical limit of statistical methods and models. As the quality of a model depends directly on the inclusion as exhaustive as possible of available information, the currently used models become obsolete due

to the increased number of records, of players, of standards to commensurate. Technically, there is no problem to update them and solutions already exist to integrate the new issues or to treat the information slightly differently. In particular, the GMACE (Genomic Multi-Trait Across Country Evaluation) was proposed in 2010 (VanRaden and Sullivan, 2010) as a commensuration tool more or less equivalent to the MACE model but adapted to genomic evaluations. Adopted by Interbull and provided as a service complementary to MACE by the "Interbull Centre", this tool did not arouse however the sufficient acceptance within the Interbull community despite its advantages similar to the MACE model, i.e. the possibility to reach the commensurability of GEBVs (Genomic Estimated Breeding Values) in the context of plurality of national standards of evaluation and without sharing strategic genotype data. Indeed, the United States, the major player on the international semen market and of the Interbull community, decided not to participate in the genomic commensuration process for reasons related to its national priorities of commercial nature. Thus, the competitiveness of the GMACE evaluations provided by the "Interbull Centre" was obviously undermined compared to the American GTPI (Genomic Total Performance Index). Other methodological novelties are also almost ready to be implemented. For example, the "Robust MACE", i.e. an updated MACE model robust to inconsistencies between national genetic trends, could facilitate and improve the assessment of technical quality of national evaluation systems in the process of their integration into the international evaluation, etc. More strategically, "Single Step" evaluations have been proposed instead of the current "two step" approach (first, a "usual" genetic evaluation, followed by a genomic evaluation combining results from the first evaluation with genomic information) in order to avoid a bias in genetic evaluations due to the pre-selection of animals based on their genome information. But the current main difficulty is to find a new compromise between more diverse players. Business players have a heavier weight than before on the balance of international evaluation system because, among other things, they are owners of the genotype data. Business arguments within the Interbull community have to account more, than before face to technical arguments. Indeed, the United States as the biggest exporter of genetic material has already integrated their industry representative into the Steering Committee of Interbull. So, the "technical" debates are framed more than before by the strategic positions of the competing trade players.

This does not mean that the issue of commensurability is less important. First of all, the "new" methods of genomic evaluation are based on the previously constructed system of commensurability of genetic values. Thanks to the commensuration process, the information about bulls from different countries with different production contexts, environmental conditions and economic objectives is still collected and taken into account by the MACE model. Thus, all national genomic evaluation models are built on the basis of huge virtual reference populations with differentiated phenotype information which allows them to be reliable. Indeed, the commensuration process gives a more comprehensive vision of the "international animal" which tends to a "universality" compared to a partial vision of the "national animal" evaluated only in national conditions.

Secondly, the question of comparability of EBVs and GEBVs within an enlarged and diversified circle of players is already and again on the table of the international debates. As forty years ago at the beginning of construction of the international commensurability, exporters of genetic material on the one hand try to build their "genetic" market with their own measure of product quality expressed by EBVs and GEBVs calculated on their own national scale and importers on the other hand are willing again to be able to compare objectively products proposed on the international market with their needs expressed on their own scale. Technical tools for a "new" or "updated" commensuration are proposed by scientists and the international negotiation (probably more complicated than forty years ago, but not necessarily) is in progress and marks a new cycle in the international order of cattle breeding.

Conclusions and discussion

What is the commensurability issue for Interbull?

We started the study of Interbull at the moment when the new technology of genomic selection brought an uncertainty on its mission which was built during several decades and seemed well established. A socio-historical analysis was necessary for a better understanding of the current situation and of ongoing processes. The application of the conceptual frame of the commensuration developed by social sciences scholars allows seeing the Interbull role from a new angle. History shows how the will of several importers of semen to compare the quality of the marketed animals led to the construction of an international space of commensurability of different national breeding standards. Inside the black box of each standard three dimensions are narrowly linked: the biological one (characteristics of the evaluated animal living in a concrete environmental context), the social one (all social, cultural, political, economic aspects of the national livestock production system) and the technical one (technologies and methodologies of measure, statistical methods and models of calculation). To commensurate these aspects all together meant for Interbull to find an optimal tool which represented a compromise between the technical exhaustivity and the political acceptability of the included information. What to make visible and what to hide? But it also means - and the occurred "genomic breakthrough" has highlighted that - that the commensurability cannot be fixed. It must be considered as an endless process continuously anticipating and adjusting new issues which could be of biological, political or technical nature. As a deeply social process, the commensuration is built by the search of a common interest and of a compromise between players (by players, we understand not only "human" stakeholders but also other participants of the process like animals, technical tools etc.). For instance, the MACE model became this optimal compromise, but it occurred after two long decades of research. With a changed technological and political situation, a new compromise is needed.

As stressed by Desrosières (2014), commensuration has a double nature: as a "tool of proof" with a technical, argumentative purpose and as a "tool of coordination" with an administrative, political purpose. The role of the transnational space of commensuration constructed step by step within Interbull around a technical tool with a "proof" function is evolving progressively to the "coordination" purpose. The issue of commensurability is still and even more on the front of the international debate and the circle of players is larger and more diversified. Indeed, for big (developed) countries in the context of liberalization of the market of genetic and genomic evaluations, as well as for new countries which want to better evaluate what to import for their own breeding systems, the question of comparability and ranking of genetic and genomic values for the estimation of product quality has the same importance than forty years ago.

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