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**Vertical integration and health control measures
in the French young beef bull sector**

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Vertical integration and health control measures in the French young beef bull sector

Abstract

The French young beef bull sector presents a complex organisation. The more animals are mixed and subjected to long transports, the more likely they will be to develop bovine respiratory disease (BRD). We aimed to understand the vertical integration patterns in the young beef bull sector and how they influence public health issues (BRD and antibiotic use). We revealed a diversity of vertical integration patterns, from spot market to vertical integration. The “health issues” parameter is involved in different categories of transaction costs (risk, uncertainty, quality). When vertical integration is strong (weak), the risk of BRD is low (high), which thus have an indirect effect on antibiotic use.

Keywords: vertical integration, young beef bull sector, animal health control measures, reduction of antibiotics use

JEL classification: D23, L14, Q13

Intégration verticale et mesures de contrôle de la santé dans le secteur des jeunes bovins de boucherie de race à viande

Résumé

Le secteur des jeunes bovins de boucherie (JBB) présente une organisation complexe. Or plus les animaux sont mélangés et subissent de longs transports, plus ils sont susceptibles de développer des bronchopneumonies infectieuses (BPI). Les acteurs de la filière utilisent aujourd'hui des antibiotiques de manière systématique et préventive pour prévenir le développement des BPI. Notre objectif est de comprendre les schémas d'organisation verticale dans le secteur des JBB et d'analyser leur influence sur des questions de santé publique (BPI et pratiques d'utilisation d'antibiotique). Nous montrons l'existence d'une diversité de schémas de coordination verticale, depuis le marché au comptant jusqu'à l'intégration verticale. Les paramètres relatifs aux questions de santé sont pris en compte dans différentes catégories de coûts de transaction (risque, incertitude, qualité). Lorsque la coordination verticale est importante (faible), le risque de BPI est important (faible), ce qui a donc un effet direct sur l'utilisation d'antibiotiques.

Mots-clés : intégration verticale, secteur des jeunes bovins de boucherie, mesures de contrôle de la santé animale, réduction d'utilisation des antibiotiques

Classification JEL : D23, L14, Q13

Vertical integration and health control measures in the French young beef bull sector

1. Introduction

Bovine respiratory disease (BRD) is widespread in the young beef bull sector. Up to 80% of French young beef bull herds can develop the disease (Timsit *et al.*, 2013). BRD triggers clinical signs such as delayed growth and even death at the beginning of the fattening period in young bulls¹ (Hay *et al.*, 2016). To control BRD and prevent economic losses, systematic preventive antibiotic treatments are frequently prescribed. However, the efficiency of antibiotics is tending to decrease, due to antibiotic overuse in the young beef bull sector (Gautier-Bouchardon *et al.*, 2014). This biological phenomenon is an extensive and growing concern worldwide (Laxminarayan *et al.*, 2013; OECD, 2014). Reducing antibiotic use is thus of paramount importance for public health to limit the spread of antimicrobial resistance. Systematic, preventive antibiotic treatments should therefore be stopped. Public regulators and the sector's stakeholders therefore need to know how to instigate a positive transition in antibiotic use to control BRD.

Current antibiotic practices (systematic and preventive antibiotic use) in the young beef bull sector can be linked to vertical integration issues. In France, a new regulation could possibly forbid any systematic and preventive use of antibiotics. This regulation represents a risk for fatteners who would be directly and strongly impacted. The production of calves (in farms raising cow-calves) is separated from the fattening of young bulls (in fattening units). This organisation implies intermediary transactions of weanlings², which increase the risk factors of BRD development (confinement, transport, stress, mixing of weanlings...). The matching of supply and demand is ensured by middlemen³. Most farmers and middlemen are independent, with very few long-term contracts (less than 20% of the sector (Marty *et al.*, 2015)). This lack of vertical integration sharply reduces the sharing of information between stakeholders. This situation is different from other animal production sectors in which market institutions with commercial long-term contractual agreements or even stronger vertical integration (e.g. pork production; broiler production (Antoine *et al.*, 2014; ITAVI, 2013))

¹ Young bulls = in this article we focus on 24 month old male beef bovines

² Weanling = Male beef calf between 5 to 9 months old.

³ Middlemen = generic term which includes all livestock traders in the sector.

have been developed (Hendrikse, 2007). A wide range of types of vertical integration governance co-exist, ranging from spot market (livestock market) to vertical integration (breeder-fattener producers). It is therefore crucial to examine the way in which vertical integration in the young beef bull sector influences the use of antibiotics.

To understand how the various governance schemes, observed during weanling marketing, affect health issues and antibiotic use in young bulls, we focussed on the characteristics of the different transactions. The transaction costs economy theory was first initiated by Coase and then developed and enriched by Williamson and other economists in the nineties. The aim was to understand the governance patterns in relation to the economic environment in a context of bounded rationality and opportunism of stakeholders (Williamson, 1985). As Lafontaine and Slade (2007, p 25) stated, “transaction costs are the costs of establishing and administering business relationships with and between firms or individuals, including those costs associated with opportunistic behaviour and haggling ex post”. This theory argues that decreasing transaction costs is a determining factor to explain vertical integration patterns. It predicts that the success of a certain shape of governance is representative of its efficiency (Bijman, 2006) and will minimise transaction costs. This economic theory has been used to describe and analyse the economic governance of transactions in agricultural contexts (Ménard, 2007). Some authors have analysed the existence of a single specific governance scheme in a mature market, or the choice of different governance schemes in a mature market (Bontems and Fulton, 2009; Feng et al., 2013; Fulton and Giannakas, 2001). Others have scrutinized the influence of transaction costs as determinants of a diversity of different existing governance schemes in transition economies (Boger, 2001).

In this paper, we address the issue of transaction costs economics in a mature market that presents different coexisting governance patterns. Our aim was to explore how economic determinants explain the existing vertical governance patterns and how these latter influence BRD development and antibiotic use in the young beef bull sector. Particular consideration was thus given to the influence of economic organisation on animal health issues, based on transaction costs economics framework.

Vertical integration patterns clearly vary between farmers, depending on the stage of production (cow-calf producer or fattener) or on their specific assets. Animal health is mostly linked to quality issues, but the definition of quality, according to the different stakeholders in the supply chain, can vary considerably. The vertical integration patterns directly impact the risk of BRD development and the possibility of implementing prudent control measures

because they increase information asymmetries. As a consequence, these patterns indirectly influence the use of antibiotics.

This paper is divided into four sections. Section 2 reviews the literature on determinants of transaction costs in the agricultural sector; Section 3 describes the general study design; Section 4 presents the results and discussion; Section 5 the conclusions.

2. Determinants of vertical integration in the agricultural sector

The economic environment is defined by different parameters: complexity, availability of information, uncertainty, frequency of transaction, specific human assets, specific physical assets, dedicated assets, geographic specificity, and temporal specificity (Williamson, 1994).

According to Williamson, assets specificity determines the terms of governance schemes: from spot market to vertical integration. Asset specificity means that this asset would lose some of its value when used in another transaction. It would generate additional costs, or it would decrease productivity. When no specific assets are involved, the best governance scheme will be the spot market. However, if specific assets are engaged in the production process, more vertical integration would avoid situations of quasi-rent associated with ex-post renegotiations and opportunism (Lafontaine and Slade, 2007). In that case, either (i) safeguards remain at a zero level and prices are higher than in the spot market; or (ii) transaction safeguards are developed by implementing long-term contractual agreements and other insurance systems, or (iii) stronger vertical integration is implemented by the integration of the firm, which can be backward or forward.

Empirical evidence largely confirms the predictions of Williamson's theory. We compare empirical studies in agriculture with the results detailed in the literature review by Lafontaine and Slade (2007) in which they showed that specific human assets, specific physical assets, dedicated assets, geographic specificity and temporal specificity all had significant influence on increased vertical integration in a wide variety of industrial sectors. Complexity, which often refers to the heterogeneity of inputs or products, and/or uncertainty in addition to specific assets tend to encourage more ex-post renegotiation and opportunism. Empirical studies show more mixed effects of complexity and uncertainty on the vertical governance pattern.

We first present the influence of assets specificity on vertical integration, then the influence of uncertainty and risks on vertical integration, and finally the influence of complexity, quality and information asymmetry on vertical integration.

2.1. Positive influence of assets specificity on vertical integration in agriculture

We first summarize the findings reported in the literature on the influence of assets specificity on vertical integration in table 1 and provided further details in the following paragraphs. We include human assets, physical assets, geographical specificity, temporal specificity, and dedicated assets.

Human assets consist of farmers' knowledge and skills (Ortmann and King, 2007). In the industrial sector, human assets are considered to mostly have a significant and positive influence on vertical integration (Lafontaine and Slade, 2007). Similar conclusions have been drawn in the agricultural sector with two studies showing a positive and significant effect (Fraser, 2005; Traversac *et al.*, 2011). However, even if there is a positive and significant link between the farmers' level of education, or between the farmers' years of experience and vertical integration, the human assets in agriculture can also be used in other activities (Traversac *et al.*, 2011). This could be particularly relevant in the French agricultural context where most farms exist in crop-livestock farming systems. The human asset specificity also depends on the farming activity considered: the human specificity is greater for technical production sectors such as dairying, than for poultry rearing.

Table 1: The effect of assets specificity on vertical integration (VI)

Author	Year	Agricultural sector	Data/Technique	Variable Examined	Effect on VI
Effect of human assets specificity on vertical integration					
Traversac, Rousset, Perrier-cornet	2011	Wine	Repeated cross sectional study (1988, 2000); Logit	0-3 scale of education level	+
Fraser	2005	Wine	Cross sectional ; Multinomial logit	Number of years growing grapes	+
			Cross sectional ; Multinomial logit	0-1 scale of education level	+
Effect of physical assets specificity on vertical integration					
Fernandez-Olmos, Rossel-Martinez, Espitia-Escuer	2009	Wine	Cross sectional; Binomial logit	1-7 scale of specificity (for the processor)	+
			Cross sectional; Binomial logit	1-7 scale of specificity (for the grape grower)	+
Boger	2001	Hog	Cross sectional; Multinomial logit	1-6 scale of specificity	+
Pascucci, Gardebrock, Dries	2012	Seven main sectors	Cross sectional; Bivariate probit model	Size (ha) ; specialisation	+
Effect of geographical specificity on vertical integration					
Pascucci, Gardebrock, Dries	2012	Seven main sectors	Cross sectional; Bivariate probit model	Local market structure; social and institutional context; 0-4 scale of geographical isolation	+
Effect of temporal specificity on vertical integration					
Goodhue, Heien, Lee, Sumner	2003	Wine	Cross sectional; Logistic regression	Acres of grapes (ha)	+
Fraser	2005	Wine	Cross sectional ; Multinomial logit	Area (ha) devoted to grape growing	+
Effect of dedicated assets specificity on vertical integration					
Fernandez-Olmos, Rossel-Martinez, Espitia-Escuer	2009	Wine	Cross sectional; Binomial logit	1-7 scale of excess capacity that a grower has to support if the grapes that were grown for one particular winery are rejected by it	+

Physical assets are of specific nature if they cannot be redeployed to alternative uses without losing productive value. In agriculture, specific assets are mostly related to investments in farm buildings. In industrial sectors, physical specific assets are usually considered to have a positive and significant influence on vertical integration (Lafontaine and Slade, 2007). Similar findings have been described for the agricultural sector with one study showing a positive and significant effect towards more upstream vertical integration (Boger, 2001) and another study a positive effect towards more downstream vertical integration, significant or non-significant depending on the considered variable (Fernandez-Olmos *et al.*, 2009). However, physical

specific investments vary a lot between production sectors. For instance, a milking parlour is more specific than a poultry barn. Investments can also have a positive influence on vertical organisation even if they are not specific.

There is geographical specificity if transport costs are high compared to the price of a given product. An increase in geographic specificity should increase the level of vertical integration. However, Lafontaine and Slade (2007) reported only one article showing a positive and significant effect of geographic specificity on vertical integration, in the coal and electricity sector. In their literature review, another paper showed a positive effect (inputs in the chemical products sector), and one showed a negative effect (manufacturing plants sector), but both effects were non-significant. To our knowledge, only one study explicitly addresses the effects of geographic specificity on vertical integration in the agricultural sector and describes a positive effect (Pascucci *et al.*, 2012). In the agricultural sector, transport costs can be high, and legal constraints might also add a limit to the long transport of live animals (duration, space, etc.). However, costs and legal constraints are highly dependent on the sector considered. For instance, transport costs and legal constraints are much higher for transporting horses than for transporting corn.

The temporal specificity of transactions has been introduced recently in the TCE and is a particularity of the agricultural sector (Ortmann and King, 2007). This element is relevant to sectors working with perishable products (e.g. fruits, meat, etc.), and takes into account the hold-up risk linked to temporal constraints. If one stakeholder in the transaction faces temporal constraints, the other might take the opportunity to renegotiate the transaction deal. More temporal specificity is thus in favour of vertical integration, both in the industrial sector (Lafontaine and Slade, 2007) and in the agricultural sector with two studies demonstrating significant positive effects (Fraser, 2005; Goodhue *et al.*, 2003). However, temporal specificity varies a lot depending on the agricultural product. This parameter is for instance more important in the poultry sector, where the production cycle is short (62 days) and the characteristics of poultry are highly standardised (size, weight), than in the corn production sector.

Dedicated assets are investments made for a particular supplier or buyer, which have no or less value outside this specific commercial relationship. Dedicated assets are in favour of more vertical integration in the industrial sector (Lafontaine and Slade, 2007). Findings in the agricultural sector are similar with one article showing a significant positive effect (Fernandez-Olmos *et al.*, 2009).

2.2. Paramount but contrasted influence of uncertainty and risks on vertical integration in the agricultural sector

Uncertainty and risks are high in agriculture (Hardaker, 2015). Uncertainty is linked to the characteristics of the exchanged products. Uncertainty cannot be measured or evaluated, whereas risk evaluates a possible loss. In agriculture, the risk for a given firm has been divided into five main types: production or yield risk (e.g. animal disease), human or personal risk (e.g. workplace accident), price or market risk (e.g. fluctuations in prices), financial risk (e.g. investment burden too high), and institutional risk (e.g. changes in regulations) (Hardaker, 2015).

The uncertainty of transactions can be linked to the behaviour of stakeholders or linked to the environment of the transactions, such as market fluctuations. Most empirical studies in diverse industrial and agricultural sectors revealed a significant positive effect of behavioural uncertainty on the level of vertical integration (Fernandez-Olmos *et al.*, 2009; Lafontaine and Slade, 2007). However, two empirical articles showed a negative but non-significant effect of uncertainty in the industrial sector (Lafontaine and Slade, 2007), and one article showed a negative and significant effect of behavioural uncertainty on long-term relationships, and thus on vertical integration (Coronado *et al.*, 2010). In this case, the authors explained that stakeholders do not want to restrain themselves with long-term contractual agreements. However, Coronado *et al.* (2010) did find a positive and significant influence of environmental uncertainty on vertical integration. In their meta-analysis, Chen *et al.* (2004) found that uncertainty in the manufacturing firms sector could sometimes support less vertical integration. In an uncertain context, there would be fewer monetary risks in having many marketing channels for selling a single product (Chen *et al.*, 2004), which would favour spot markets. This reluctance to develop long-term relationships can be enhanced as uncertain contexts often have negative effects on trust. However, trust is a very important element when developing long-term relationships (Geyskens *et al.*, 1998). The level of uncertainty linked to human behaviour is dependent on the bargaining power between stakeholders and on a possible hold-up by one of the stakeholders. In agricultural sectors, this can vary considerably depending on the type of production and the general organisation of the sector.

Uncertainty is also linked to environmental uncertainty (market fluctuation (price and volume), climate, etc.). Environmental uncertainty linked to meteorological changes is important in agriculture, especially as the products are of biological nature and susceptible to diseases and weather conditions. This uncertainty is higher than in most industrial sectors.

The market fluctuation uncertainty depends on seasonal variations that can be predicted, but also on international prices changes that are partly unpredictable. As the environmental uncertainty level increases, the effects on vertical integration in agricultural and industrial sectors are positive (table 2; Lafontaine and Slade, 2007).

When the exchanges involve live animals, uncertainty is of paramount importance. Indeed, the future potential growth of animals is uncertain and depends on past, present and future events, such as a disease.

Table 2: The effect of uncertainty and risk on vertical integration (VI)

Author	Year	Agricultural sector	Data/Technique	Variable Examined	Effect on VI
Uncertainty and vertical integration					
Fernandez-Olmos, Rossel-Martinez, Espitia-Escuer	2009	Wine	Cross sectional; Binomial logit	1-7 scale of the degree to which it is difficult for the winery to know the real effort made by the grower in the absence of monitoring (behavioural uncertainty)	+
				1-7 scale of the perceived uncertainty in grape yield and quality (environmental uncertainty)	+
Coronado, Bijman, Omta, Lansink	2010	Fresh products (avocado)	Cross sectional; Regression	1-7 scale of behavioural uncertainty about payment	-
				1-7 scale of environmental uncertainty about price is positively related to behavioural uncertainty about payment	+
Risk and vertical integration					
Hernandez-Espallardo, Arcas-Lario, Marcos-Matas	2012	Fresh fruits and vegetables	Cross section; Regression	0-10 scale of price satisfaction 0-10 scale of safeguards satisfaction	+

An increased level of risk is in favour of vertical integration, both in the industrial and agricultural sectors (Hernandez-Espallardo *et al.*, 2012; Lafontaine and Slade, 2007). This effect is positive and significant in the agricultural sector.

The risk linked to production is high and is intrinsic to the nature of the products in the agricultural sector: animal and plant products might suffer from a disease outbreak, either because of external contamination, or because of an internal disease. Both elements should lead to the development of vertical integration in the agricultural sector.

In agriculture, the farmers' market risk is increasing due to greater price fluctuations. Market fluctuations depend on the boosted globalisation of markets and industrialisation. International markets vary a lot on a monthly and yearly basis, thereby increasing the risks incurred by farmers (Meuwissen *et al.*, 2001).

The financial risk can be considered as a trade-off between investments and the market risks sector (Traversac *et al.*, 2011). The importance of specific assets in agriculture combined with the importance of market risks should be in favour of vertical integration because market fluctuations endanger the returns on investments (Fernandez-Olmos *et al.*, 2009). However, financial risk also varies considerably on an individual basis, depending on the farming system and linked investments.

2.3. Positive but varying influence of complexity, quality and information asymmetry on vertical integration in the agricultural sector

In agriculture, value creation through product differentiation is a crucial issue. Horizontal differentiation of products is linked to the co-existence of a wide variety of the same types of products on markets, but presenting different characteristics.

As the horizontal differentiation of products increases, complexity increases too. In a given sector, complexity is linked to difficulties in handling a wide number of intermediate production steps and routine organisation to produce a product (Mesquita and Brush, 2008). Complexity can also be approximated by the heterogeneity of a given product (Lafontaine and Slade, 2007). In diverse industrial sectors, most empirical studies (8) showed a significant positive effect of complexity on vertical integration. However one study showed a significant negative effect, and another demonstrated a U-shaped effect (Lafontaine and Slade, 2007). Complexity (as well as uncertainty) are two elements which complicate the building of complete long-term contracts and their reinforcement over the duration (Lafontaine and Slade, 2007). As complexity (and uncertainty) increase, the incompleteness of long-term contractual agreements also increases. This could explain the contrasted influence of complexity on vertical integration. We did not find any empirical analysis evaluating the effect of complexity on vertical integration in the agricultural sector. We can assume, however, that such complexity might vary a lot depending on the sector. For example, cereal production or poultry production are usually highly standardised. In contrast, the diversity of animals in the beef sector is large and depends on the breed, age, weight, etc.

The vertical differentiation of products depends on the succession of stakeholders involved in achieving high quality products in the value chain. Product quality is therefore a very important characteristic in TCE as it interacts with vertical integration choices (Goodhue *et al.*, 2003). Quality refers to the level of desirable characteristics of a product. The definition of quality usually enjoys a consensus among stakeholders, who agree to pay a premium for quality. Goodhue *et al.* showed that the level of product quality has a significant positive influence on vertical integration in the agricultural sector. Fernandez-Olmos *et al.* show a significant positive influence of quality for high added value products, but a negative non-significant influence of quality for low added value products (Fernandez-Olmos *et al.*, 2009). Fraser shows a non-significant negative effect (Fraser, 2005). Measurability of products quality in agriculture varies across sectors. For example, animal weight could be a good proxy for estimating hog quality (Boger, 2001), but is not sufficient. Non observable or measurable attributes such as meat quality are only estimated after the transaction. In addition, in the agricultural sector, quality also depends on random effects (Boger, 2001; Hernandez-Espallardo *et al.*, 2012). Random effects (disease, feed nutritional values and environmental conditions, for example) are of particular importance when exchanging live products, such as animals.

Table 3: The effect of quality, and information on vertical integration (VI)

<i>Author</i>	<i>Year</i>	<i>Agricultural sector</i>	<i>Data/Technique</i>	<i>Variable Examined</i>	<i>Effect on VI</i>
<i>Quality and vertical integration</i>					
Fernandez-Olmos, Rossel-Martinez, Espitia-Escuer	2009	Wine	Cross sectional; Binomial logit	0-1 scale of added value	- +
Goodhue, Heien, Lee, Sumner	2003	Wine	Cross sectional; Logistic regression	Regional price (\$/tonne)	+
Fraser	2005	Wine	Cross sectional ; Multinomial logit	Regional price (\$/tonne)	-
<i>Information, efficiency and quality</i>					Effect on efficiency
Coronado, Bijman, Omta, Lansink	2010	Fresh products (avocado)	Cross sectional; Regression	1-7 scale of information exchange	+*
					Effect on product quality
Coronado, Bijman, Omta, Lansink	2010	Fresh products (avocado)	Cross sectional; Regression	1-7 scale of information exchange	+*

As quality interacts with stakeholders' vertical integration, information flows along the value chain are essential to trace and control for quality attributes. If the quality is difficult to measure, having premium prices for quality might be costly to implement and control (Goodhue *et al.*, 2003). In this case, the system would tend to favour more vertical integration and long-term relationships to insure the level of quality (Goodhue *et al.*, 2003; Raynaud *et al.*, 2005). If quality is difficult to measure, an asymmetry of information might occur. This can lead to adverse selection effects (Akerlof, 1970). Coronado *et al.* (2010) showed that increased information exchange in the agricultural sector increased the efficiency of the value chain and products quality.

3. General study design

3.1. General context of the French young beef bull sector

The young beef bull sector is dedicated to beef production. When estimated in Livestock units (LU), France is ranked first in Europe (E-27) for raising young bulls (4.1 million beef cows)⁴.

The young beef bull sector produces two kinds of animals: weanlings (male beef calves between 6 to 8 months old) and young bulls (male beef less than 24 months old). Half the weanlings are exported, mostly to Italy (74% in volume) and Spain (12% in volume)⁵. The other half is fattened in France. However, most of the young bulls produced are not destined for French consumers because of the latter's preference for redder meat. Most young bulls' meat is exported to Italy, Germany, Spain and Greece. There is competition for price and volume on both the weanlings and young bulls market, but no possibility for a quality premium.

There are approximately 93 000 farms with more than 5 suckling cows in France⁶. Many different stakeholders are involved in the sector because they raise, sell or fatten weanlings (Timsit *et al.*, 2011). This sector is poorly coordinated and the level of coordination is not evolving. Farmers are independent and own their animals. This differs from other meat production sectors (poultry, pork), where the importance of the spot market has decreased considerably (Hendrikse, 2007) and the main stakeholders are coordinated within

⁴ Idele, Dépliant Chiffres clés 2016.

⁵ Idele, Dépliant Chiffres clés 2016.

⁶ Idele, Dépliant Chiffres clés 2016.

cooperatives and investor-owned firms (S. James *et al.*, 2011). The coexistence of spot markets and long-term contracts is one of the characteristics of the bovine sector (Hendrikse, 2007). The use of long-term contracts in the young beef bull sector is particularly rare (less than 20%) (Marty *et al.*, 2015).

Figure 1: Distribution of cow-calf producing units, young bull farms and slaughterhouses in France (Source: Idele, Chiffres clés, 2016)

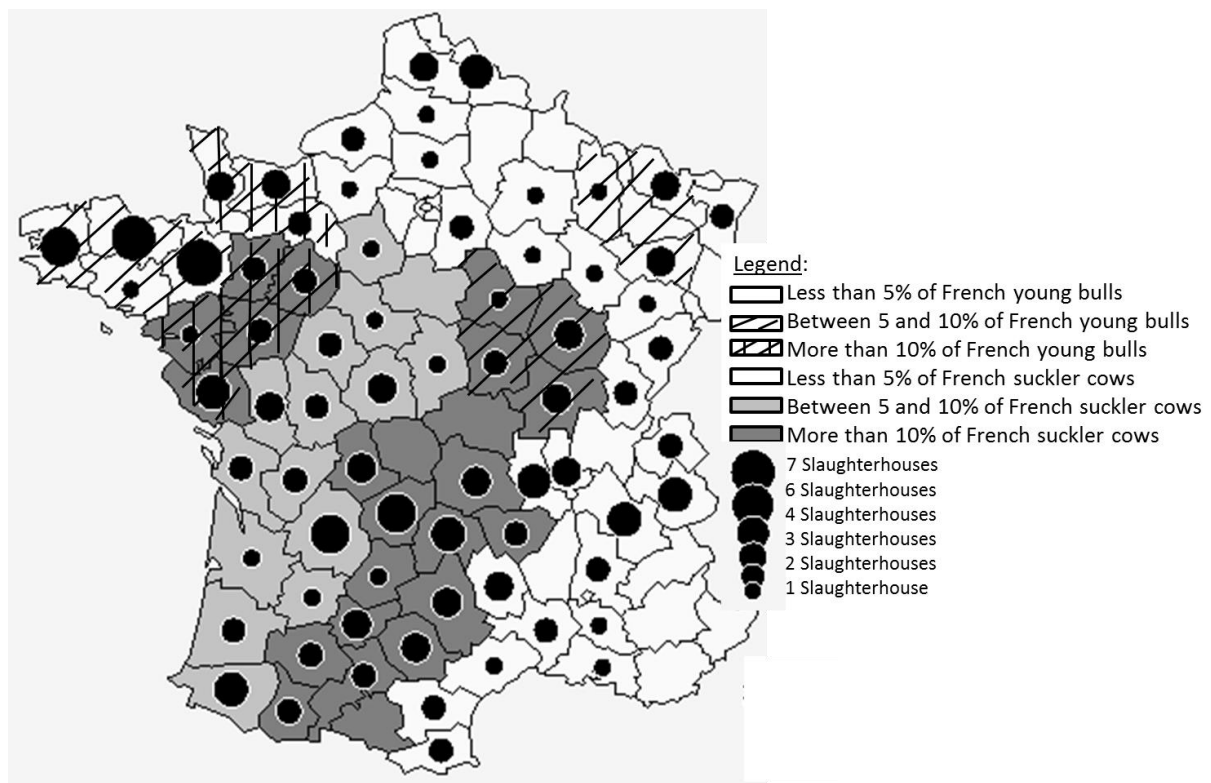


Table 4: Distribution of major stakeholders upstream in the young beef bull sector
(Source: Idele, Chiffres clés, 2016)

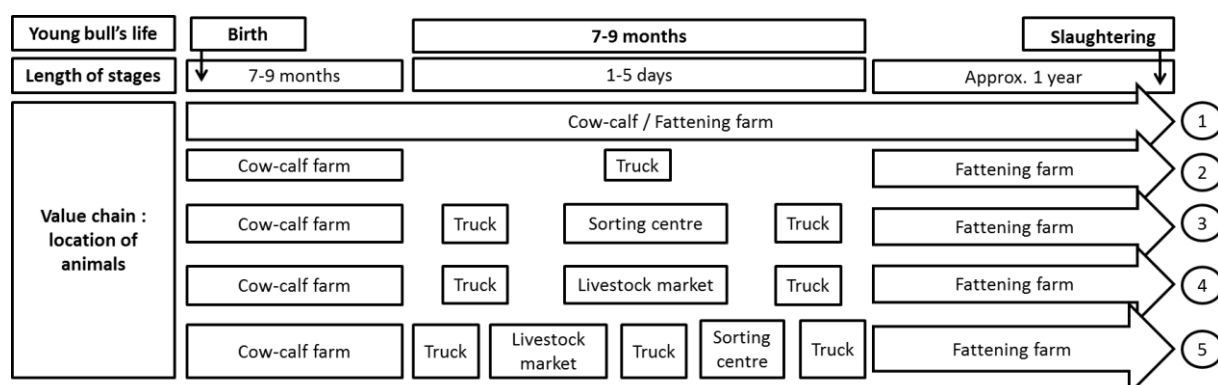
<i>Cow-calf producer and fattener</i>	<i>Cow-calf producer</i>	<i>Intermediaries*</i>		<i>Fattener</i>
		<i>Independent middlemen business</i>	<i>Producers’ organisation</i>	
11 900	49 700	1300	117	12 700

**Number of intermediaries is underestimated because independent middlemen businesses often employ more than one middleman, and producers’ organisations always employ more than one middleman*

Different systems of vertical integration coexist in the young beef bull sector. First, young bulls might be raised until slaughter in the same farm (cow-calf and fattening system Figure 2, line ①), this production system counts 11 900 farms (Table 4). We used this vertical integration system as our reference level as it corresponds to perfect vertical integration as cow-calf producing phase is integrated by fatteners.

Second, young bulls might be produced at a cow-calf producer unit and then sold at the age of 7 to 9 months (weanlings) to a fattener. There are 49 700 cow-calf producing farms, located mostly in Central France, and 12 700 fattening farms in Western and Eastern France (Figure 1, Table 4). The transaction between the cow-calf producer and the fattener can be done without intermediaries (Figure 2, line ②). However, in most cases, the transaction involves a middleman. Middlemen play a paramount role: they match the offer of cow-calf producers with the demand of fatteners. The demand of fatteners is quite regular and the fattening process more standardised. Batches of 8 to 12 weanlings are required for fattening so buyers look for weanlings with the same body condition and size. In doing so, they can fatten all their weanlings during the same period and more easily control optimal the filling of their buildings. However the supply from cow-calf producers is more irregular, depending on the season and varying on a weekly basis. First the mating of cows is naturally seasonal and the weanlings market tends to be saturated in autumn. Second, most cows are still mated by natural servicing. Synchronised breeding programs are thus difficult to implement. Consequently, cow-calf producers rarely sell ten weanlings at the same sale, but more often propose 2 to 3 weanlings with similar characteristics (age, weight, and size). Most commercial structures have a sorting centre for gathering weanlings and reorganising the batches. Middlemen can handle the logistic issues thanks to these sorting centres.

Figure 2: Existing vertical commercial routes in the young beef bull sectors from cow-calf production to fattening (source: authors' elaboration)



Producers' supply and fatteners' demand explain the logistic issues of this sector and the role played by middlemen. To match the demand of the fatteners with the supply from the cow-calf producers, middlemen buy up weanlings and then try to fit the demand of fatteners. They have several weanling suppliers: cow-calf producers, livestock markets and other middlemen. There are 47 livestock markets in France⁷. Depending on the demand, they are sometimes left with unsold weanlings. They may then sell them again to livestock markets or to other middlemen. This "matching process" occurs on a weekly basis and explains the diversity of stakeholders (Timsit *et al.*, 2011) and the complexity of the different commercial routes (Figure 2, lines ③, ④, and ⑤). Very few weanlings are sold under long-term contractual agreement.

3.2. Selection of interviewees, and analytical method

We chose qualitative method because of the very high complexity of the young beef bull sector and the lack of a precise knowledge of its functioning. The semi-structured interview approach is designed to describe a wide range of possible circumstances regarding a certain field, rather than to evaluate a question in a quantitative and representative way (Kvale, 1996; Sivertsson and Tell, 2015). This qualitative method allows a wide range of topics to be taken into account.

Qualitative semi-structured interviews were carried out with farmers (24) and other major stakeholders in the young beef bull sector (30), such as the bosses of middlemen or the

⁷ Source: FMBV

managers of meat producers' unions (Appendix 1 for more details). Stakeholders were located in the two main production regions: Central and Western France. Field observations were also carried out (6). All these elements were then combined to describe the determinants of transaction costs and to construct and explain a diagram of the existing vertical integration patterns.

The length of the interview (approximately two hours) was in favour of more authentic discussion, even if an ex-post re-organisation of personal histories is always possible (Brinkmann and S. Kvale, 2015). Interviews were based on four main questions: (i) general presentation of personal career and professional structure, (ii) everyday interaction with other stakeholders in the sector, (iii) practices regarding health management and antibiotic use, (iv) understanding of current changes, fears and motivation linked to future prospects.

A grid was drawn up to analyse the different interviews. When the interviewees were farmers, we could directly observe how they described the different determinants of transaction costs (specificity of assets, market risks, complexity, uncertainty, information availability, etc.), and which vertical integration pattern they chose.

When the interviewees were stakeholders, their description of the sector regarding the different determinants of transaction costs, and their global depiction of the vertical integration patterns in the sector, were examined.

We also analysed more specifically how all the interviewees considered animal health and BRD issues. We then integrated these issues into the analysis of transaction costs. By combining these different elements, we were able to construct a general picture of the influence of the determinants of transaction costs on the observed vertical integration patterns and animal health.

4. Results

In the young beef bull sector, the governance scheme comprises several main patterns, ranging from highly to poorly integrated systems: (i) total vertical integration, (ii) written long-term contractual agreement, renewable on a yearly basis or for a longer period of time, (iii) oral commitments also called relational contracts, (iv) spot market.

These different forms of coordination differ between the cow-calf and fattener farms. Almost all cow-calf producers sell their weanlings through less coordinated marketing channels such

as spot markets (livestock markets and/or middlemen with no long-term contracts). There are two exceptions: breeder-fattener producers; cow-calf producers selling their products directly to a fattener through relational contracts. Fatteners can implement all these forms of coordination patterns depending on their economic determinants.

4.1. Determinants of transaction costs in the young beef bull sector and potential effects on vertical integration patterns

The major issues in the sector appeared to be information asymmetries and quality. The information asymmetries were strong and seem to be linked to poor vertical integration. Quality is very diversely measured by stakeholders, and depending on the criterion, can be difficult to assess. Both issues (information and quality) are jointly evolving.

4.1.1. In most cases, low asset specificity in the young beef bull sector

The level of specific human assets was low, even if human assets were more important for cow-calf producers than for fatteners. Cow-calf producers indeed face greater risks associated with the management of difficult stages such as calving or mating cows, which require specific knowledge and skills. Although the fatteners' skills are also important, they tend to focus on one stage in the rearing process. All stakeholders confirmed this statement, farmers included. However, these assets are not specific to a given transaction and they are useful whatever the commercial path used to sell or buy animals. Farmers often have a broad knowledge of agricultural sciences, which enables them to use their skills for different agricultural activities and sectors. In our interviews, several farmers and stakeholders explained that some farmers were able to give up animal farming to orientate their farm toward crop productions in order to improve their quality of life and economic situation.

The level of specific physical assets was low. Both cow-calf producers and fatteners reported limited levels of physical investments. In addition, investments in barns or farm equipment are hardly specific to a transaction. All interviewees confirmed this point of view.

The level of geographic specificity was very low. Non-geographic specificity is greater in the young beef bull sector because the animals can be transported over long distances, for a negligible cost (approximately 3% of the weanling price for a distance of 350km). According

to the interviewees, all the commercial destinations of French weanlings could easily be reached without any extra costs linked to animal welfare regulations or transportation fees.

However, location is an important determinant of the nature of agricultural production on farms. Weanlings are reared in central France whereas young bulls are fattened in western France. The reason is linked to climatic conditions and to specific regional features. Western France is a region with multiple agricultural activities (cereals, poultry, pigs, dairy cows, etc.) and there is fierce competition for space. Fattening is carried out in barns and thus requires a limited area. In addition, the by-products from cereal productions can be used to feed the animals. In Central France, there is little competition for land use, but the soil is not fertile enough for efficient cereal production. The activity of cow-calf producer thus makes use of fields that might not be used otherwise.

While the geography criterion influences production choices, farmers can always sell their animals through different channels whatever their geographic area of production. In addition, the length of transport and logistics issues did not seem to determine the choice of marketing channel. However, this geographic specialisation of production does limit direct oral or long-term contracting between cow-calf producer and fattener. As the two production stages are some distance away from each other, cow-calf producers and fatteners cannot meet and thus cannot conclude direct agreements. Vertical integration schemes are thus limited and depend upon the region.

The level of temporal specificity is very low for cow-calf producers and low for fatteners. In the young beef bull sector, production cycles are long (on average 20 months to produce a young bull).

Depending on the farmers' habits and choices, weanlings can be sold from 5 to 10 months on the weanlings' market, with no depreciation of their value. However, extending the time that weanlings stay on the farm comes at some additional costs (space, food). Therefore, the time flexibility varies according to each individual farm. However, few farmers expressed strong constraint about that point.

Some fatteners stated that the financial pressure they faced increased the level of temporal specificity in their transactions, as they needed to optimally use the fattening space in barns. This could lead to more vertically coordinated forms of governance.

The level of dedicated assets is moderate for cow-calf producers and high for fatteners. This difference between cow-calf producers and fatteners can be explained by the nature and

economic value of the dedicated assets. For the cow-calf producers, the vaccination protocol to protect weanlings against BRD, which is done before sale, is considered as a specific asset. However the cost of vaccination only concerns 5% maximum of the total weanling price (approximately 40€, that includes vaccine and work force; approximately 800€ for a weanling of 300kg). For the fatteners, we do consider that the weanlings are a specific asset. The economic burden of weanlings is very high (approximately 800€/weanling) and influences the forms of governance toward more vertical integration.

4.1.2. Moderate to high levels of uncertainty and risk in the young beef bull sector

All stakeholders in the young beef bull sector felt a high level of uncertainty and risks based on the considerable risks of production associated with potential outbreaks of disease. For the cow-calf producer, the production risks are multiple because farmers face health risks having different origins: calving is a critical step, then calves can develop diarrhoea, respiratory diseases, etc. However, all those risks are linked to the health control measures implemented by the farmers on their farms. For the fatteners, the production risks are “mono risk”, as they are only linked to BRD. However the level of BRD risk is highly dependent on the health control measures and disease events happening during the upstream steps before fattening. Human risks and financial risk associated with investments and market fluctuations are also important. Perception of financial risks varies among farmers depending on their economic burden. Very few stakeholders expressed concerns about institutional risks.

The importance of the market risk and uncertainty in the young beef bull sector will be examined more thoroughly as this point was most frequently brought up by the interviewees, and was moderate (high) for the cow-calf producers (fatteners) respectively.

The difference in risk perception linked to market fluctuation by stakeholders has different causes. First, if a certain level of market price fluctuation can be predicted (e.g. seasonal variation in weanling supply); other variations are linked to the opening or closing of export markets. For example, during spring 2016, the Turkish demand for weanlings was high and unusually increased the market price of weanlings on the French market. However, the market closed shortly after this period, and the price went back to its more usual variations. Another example is linked to the different outbreaks of blue tongue, which stopped animal movements and penalised French exportation of weanlings, even with traditional clients such as the Italians. The general uncertainty of market fluctuation was shared both for weanlings and

young bulls. However, as young bulls are exported after slaughter, this market was less concerned by disease outbreaks, such as blue tongue, as there was less restriction on commercial exchange involving processed meat.

Second, market prices for weanlings and young bulls are negotiated and determined in euros per kilogram of live animal bodyweight. Thus for a same level of market fluctuation in €/kg, the total price variation is lower for a weanling than for a young bull. For example, a reduction of 3 cents/kg of live bodyweight has a repercussion of 75€ on a 250 kg weanling and a repercussion of 225€ on a 750kg young bull.

Finally, cow-calf producers are faced with a “single” market risk, linked to the price fluctuation of weanlings, whereas fatteners are faced with “multiple” market risks, including the market fluctuations of both weanlings and young bulls. The two market prices are not well correlated, due to the large proportion of exportations. For example, the demand for weanlings might increase (e.g. demand by a new country) and the demand for young bulls might decrease at the same time (erosion of meat demand on traditional markets), which make both prices change in opposite directions, thus reducing the fatteners’ margins.

4.1.3. High levels of complexity, quality and information asymmetry in the young beef bull sector

The horizontal and vertical differentiation of the young beef bull sector has an effect on vertical integration. This is linked to the different transaction costs associated with these differentiations. Horizontal differentiation deals more with the complexity of the sector. The weanlings sold on the market are very diverse, depending on different attributes such as breed, weight, and official disease status. Vertical differentiation has more to do with quality and information asymmetry.

Horizontal differentiation of the weanling market, which is in favour of less vertical integration, is great. This offer diversity, considered as a high level of complexity, mirrors the diversity of the demand. For example, French fatteners tend to demand ‘light’ weanlings, whereas Italian fatteners prefer heavier weanlings. Some French fatteners ask for officially certified disease-free animals, others do not require any certification of this nature. There is no official price premium on the quotation linked to these characteristics; it is more a system based on individual preferences. This broad horizontal differentiation introduces a high level

of complexity into the weanling market. This might have a negative effect on the level of coordination, as cow-calf producers have numerous options to sell their weanlings.

This complexity of the market is linked to the complexity of existing marketing channels. Cow-calf producers (fatteners) can sell (buy) animals through middlemen, livestock markets, or directly to fatteners (cow-calf producers). And those channels are not exclusive.

Vertical differentiation involves the different stakeholders in a vertical value chain and is linked to the levels of quality and associated price premiums. However, on the weanlings' market and through stakeholders' interviews, we observed 1) very diverse criteria associated with a definition of quality, furthermore difficult to evaluate *ex-ante*, 2) no price premium associated with the quality of young bulls, some examples apart, but accounting for a negligible volume.

The quality of the exchanged animals (weanlings or batches) is hard to measure in the young beef bull sector. Indeed, as young bulls are live products that are to undergo fattening, their quality is linked to their ability to grow quickly at minimal cost. Weanlings' characteristics at a given moment t determine their future and good performances at a given moment $t+1$. This ability is linked to many factors (past disease events, animal feed, etc.) but is nevertheless unpredictable *ex-ante*.

The choice of attributes to approximate "quality" varied a lot depending on the stakeholders' point of view (cow-calf producer, middlemen, fatterer, or veterinarian) (Table 5). Cow-calf producers choose criteria that minimise their costs to produce and sell weanlings. Middlemen and fatteners prefer criteria that reflect the homogeneity of batches. Their aim will be to buy or sell the whole batch at the same time, with no young bulls left in semi-empty barns until they reach the optimal weight for slaughter. Except for regulatory constraints and official vaccination (Table 5), all stakeholders, except veterinarians, neglect health and logistical criteria. Because they focus on attributes linked to a homogeneous batch size, middlemen and fatteners neglect both health characteristics (e.g. vaccination against BRD) as well as logistical characteristics (e.g. number of farms of origin or duration of transportation). This choice might have the opposite effect to the one expected as it leads to size heterogeneity within the batches during the fattening period. This effect is limited when the batches are composed of weanlings of heterogeneous size at the beginning of fattening but coming from the same cow-calf producing unit. In this case, size heterogeneity might be reduced during the fattening period. In addition, the current criterion chosen to constitute weanlings batches

increases the risk of developing BRD (Ackermann *et al.*, 2010; Assié *et al.*, 2009; Sanderson *et al.*, 2008), and thus favours the systematic and preventive use of antibiotics.

Table 5: Different stakeholders' points of view, collected during semi-structured interviews, regarding the preferred and usual criterion to define the quality of weanlings (W) or weanlings' batch (B)

<i>Stakeholders' points of view on quality attributes required*</i>	<i>Cow-calf producer</i>	<i>Middlemen</i>	<i>Fattener</i>	<i>Veterinarian</i>
<i>Zootechnical characteristics</i>				
Uniformity (size) of batches		B	B	
Breed	W	W - B	W - B	
Weight	W	W - B	W - B	W - B
Potential daily weight gain		W - B	W - B	W - B
Beef conformation		W - B	W - B	
<i>Logistical characteristic</i>				
Farm of origin		W		
Number of farms of origin				B
Number of transitional intermediaries				W - B
Duration of transportation				W - B
<i>Health characteristics</i>				
Official vaccination	W	W - B	B	W - B
Past disease events				B
Health prevention (antibiotics)		W - B	B	W - B
Health prevention (vaccination against BRD pathogens)		W - B	W - B	W - B
Health prevention (Anthelmintic treatments)		W - B	W - B	W - B

**Highlighted boxes correspond to the opinion of stakeholders regarding the most important points to define quality or desirable attributes of weanlings or weanling batches.*

When cow-calf producers sell weanlings, there is almost no existing price premium (with the exception of some long-term or relational contracts), even though the market prices can differ depending on the breed (up to 20%, but usually less than 10%). Beyond this apparent uniformity of prices and the disparate criterion of quality, a mixed formal and informal system of quality has been developed on markets (and adapted according to cow-calf, middlemen and fatteners' criteria). Each week, livestock markets provide a formal quotation for weanlings depending on their breed, age and weight which serve as a benchmark for price negotiations during the transactions. An informal system then allows a discussion of prices depending on the appearance of the weanlings, their age, batch uniformity, and other criteria cited in table 5. However, despite the mixed formal and informal fixation of prices, there is no clear price

premium for established quality criteria. This does not encourage cow-calf producers to improve the quality of weanlings.

Both the lack of vertical integration and the quality valuation of weanlings or weanlings' batches are strongly linked to the considerable asymmetry of information. An abrupt decrease in the level of this information transfer is observed between cow-calf producers and downstream in the sector. At each transaction, there is a loss of information, which is linked to a loss of efficiency.

The cow-calf producer has information on each animal's health status (official and personal records of disease events and medical treatments on farm), its age and weight. The first intermediary can be aware of those events if he knows the cow-calf producer well enough. But rapidly after the weanling is sold by the cow-calf producer, the only remaining information is written on two official documents: (i) the passport which indicates the identity of the animal (identification number, farm of origin, age), (ii) on the back of the passport, the green card, which indicates the health status of the last farm where the animal was (but only for notifiable diseases) and all the past owners of the animal. The two documents are compulsory for every transaction. The weight of the weanling is also roughly estimated by stakeholders or precisely measured with a balance. The age/weight ratio gives a rough idea of the good health (present and/or past) of the weanlings.

However, there are two major limitations to development of an efficient information flow from upstream to downstream in the sector. First, when fatteners conclude the transaction to buy weanlings, they only have information about their weight, but not even on the abovementioned elements. Second, the abovementioned elements available ex-post (written on official documents and weight) are not precise enough to predict the subsequent performances of the animal or the risk of it developing BRD. To reduce BRD risks, factors such as logistical or health characteristics, need to be considered.

The information asymmetry issue increases the difficulty of collecting information about animal quality and properly highlighting the quality attribute of weanlings in transaction negotiations. This high level of information asymmetry reduces the degree of vertical integration.

Two exceptions were reported. Both used additional criteria to define quality and value quality with a price premium (given to cow-calf producers and paid by fatteners). The first one took into account the implementation of a vaccination protocol against BRD and valued

this investment through a price premium. This was formalised in a long-term written contract offered by a cooperative. The second one took the vaccination protocol, the farm of origin and the number of farms of origin into account. This was not formalised, but established by an oral long-term contract by the middlemen for a niche fattening market (Holland, Belgium, Northern France).

4.1.4. Influence of transaction costs to explain different observed vertical integration schemes

Based on the interviews, one important hypothesis underlying the following analysis is that cow-calf producers and fatteners develop different farming systems, in different geographic areas, under different constraints, under different economic environments, etc. resulting in different transaction costs and diverse effects on vertical integration (Table 6). In Table 6, we first present the level of transaction costs we estimated from the interviews (from very low to very high) depending on the farm activity (cow-calf producer or fattener). Then, based on the interviews, we exposed the influence of these transaction costs on vertical integration (from no influence to idiosyncratic influence). Not all transaction costs seemed to influence the level of vertical integration.

Table 6: Overview of transaction costs, as evaluated through interviews and field observations. Potential influence of transaction costs on vertical integration in the young beef bull sector (source: author's elaboration)

Transaction costs observed	Level of observed transaction costs*		Observed influence of transaction costs on vertical integration**	
	Cow-calf producers	Fatteners	Cow-calf producers	Fatteners
Human specific assets	-	-	0	0
Physical specific assets	-	-	0	0
Geographic specificity	--	--	0	0
Temporal specificity	--	-	0	1 ⁺
Dedicated assets	+	++	1 ⁺	1 ⁺
Uncertainty and market risk	+	++	1 ⁺	1 ⁺
Complexity	++	+	2 ⁻	1 ⁺
Information asymmetry	--	++	0	2 ⁻

* - -: very low; -: low; +: moderate; ++: high

** 0: *Ceteris paribus*, transaction costs having no influence on vertical governance; 1: *Ceteris paribus*, transaction costs having an influence (⁺positive or ⁻negative) on vertical governance depending on individual characteristics; 2: *Ceteris paribus*, transaction costs having an idiosyncratic influence (⁺positive or ⁻negative) on vertical governance.

Cow-calf producers mostly transact on spot markets and have no long-term contractual agreement (Appendix 2 for more details). Regarding their previously described transaction costs, the low level of vertical integration observed was mostly influenced by the complexity of the weanlings' market, and sometimes by the market risk. Cow-calf producers have limited specific assets in an economic context of uncertainty, no price premium for quality (understood as animals vaccinated against BRD, improved characteristics of batches) and complexity. The whole picture is thus in favour of spot markets. However, two kinds of exception exist, where cow-calf producers sell weanlings through relational contracts or through a written long-term contract. In certain forms of relational or written long-term contracts, the transactions are associated with a price premium for a quality attribute: early vaccination of young bulls. The price premium compensates the investments in a vaccination protocol (biomedical material, worktime, etc.) through a more coordinated form of transaction. In the case of the relational contract, we observed a quasi-direct contact between the cow-calf producer and the fattener. The relationship is initiated by the cow-calf producer or the fattener, and information asymmetry is reduced to a minimum. In the case of written long-term contracts, the relationship is initiated by middlemen. Information asymmetries are reduced to allow the valuation of a given quality attribute, but the information asymmetry is still large.

The uncertainty and risk might affect vertical integration but cow-calf producers often mitigate risks as weanlings are only one type of product sold by the farm. In addition, they receive substantial financial support from the Common Agricultural Policy (CAP), which can be up to 33% of the farm income.⁸ Financial support is linked to the geographic location (systems with a natural handicap), or the nature of production (support for extensive systems, support for suckler cows, etc.). This tempers the risks linked to market fluctuations.

Fatteners transact under all forms of vertical integration, from spot market, to perfect vertical integration, in the case of cow-calf and fattening farms, sometimes using different forms of vertical integration simultaneously. This diversity of levels of vertical integration is mostly influenced by the major information asymmetry observed in the sector. Information asymmetry diminishes as the level of vertical integration increases. Information asymmetry is non-existent in the case of total integration, and considerably diminished in the case of a direct agreement between a cow-calf producer and a fattener. Nevertheless there is a loss of information even in the case of a long-term written contractual agreement. The information

⁸ Prices and margins observatory (*Observatoire de la formation des prix et des marges*), 2015.

(vaccination, animal feed, past diseases, etc.), exists but is not transmitted. Some farmers did implement a proper vaccination protocol to protect animals against BRD at the beginning of the fattening period, but the information was not demanded by or transmitted to middlemen. In all cases, the greatest asymmetry and loss of information coincides with the intervention of middlemen. They are furthermore of paramount importance in dealing with the geographic distribution of farmers and with the complexity of the weanling offer.

Other transaction costs also influence the fatteners' choice of the level of vertical integration. These depend on more individual characteristics, such as the level of temporal specificity, the level of dedicated assets, the uncertainty and risk linked to market fluctuations, and the complexity of the transactions. As the costs of all these factors increase for fatteners, the level of vertical integration also increases. For example, certain forms of written long-term contracts allow both the dedicated assets (through cash-flow advance) and the market risks (agreement on prices, investments), etc. to be taken into account. Fatteners often mitigate the market risk by developing different agricultural activities so that fattening only accounts for a part of their revenue.

4.2. Influence of vertical governance on animal health issues and systematic preventive antibiotic use

Stakeholders in the young beef bull sector need to coordinate their actions to be more productive than if each one is working alone. Indeed, if the performances of young bulls during the fattening period depend on the know-how of fatteners, they are also highly dependent on the way the weanlings were raised. The weanling's history includes, from birth to the beginning of fattening: (i) ease of birth, feeding practices, vaccination, disease events (diarrhoea, BRD, etc.) at the cow-calf producer's farm; (ii) duration of transportation, number of mixes of weanlings, number of intermediaries,... during the transfers involving middlemen. We define these points as being quality attributes of weanlings. In the current situation, the vertical organization of the young beef bull sector is therefore creating technical interdependency of the fattener with upstream in the sector.

Animal quality is best taken into consideration in the most integrated vertical integration system (Figure 2 lines ①), as there is no transporting, no mixing of weanlings and no intermediaries. In all the other vertical integration systems, the risks of BRD are increased due to the transporting and mixing of animals (Figure 2 lines ②, ③, ④, and ⑤). The technical

interdependency of the fattener is particularly strong when BRD risks are considered (Table 7). Indeed, the distribution of risk between the various stakeholders is very unequal. The risk of BRD development only affects the fatteners. However, the upstream vertical organisation of the young beef bull sector currently involves numerous mixings of weanlings. Mixing of weanlings and long transportations promote bovine respiratory diseases (BRD), because they permit microbial exchanges, and involve confinement and stress (eg. Ackermann *et al.*, 2010; Assié *et al.*, 2009; Sanderson *et al.*, 2008). The longer the exchanges, the greater the risks of BRD development. Sorting centres and livestock markets are places where microbial exchanges are particularly rife. In fattening units, the greater the diversity of cow-calf farms providing the weanlings in a given batch, the greater the risk of developing clinical BRD. If exchanges of weanlings and long transportation are involved, the risk of BRD development can be as high as 85%.

To control the important risk of BRD development at minimum cost, fatteners systematically administer a preventive antibiotics treatment just before the riskiest period, i.e. the first fifteen days of fattening (Figure 3). Antibiotics thus have a particular economic role in the vertical organisation of the young beef bull sector, as they almost erase the technical dependency of fatteners on the upstream portion of the sector.

However, from a public health point of view, the systematic preventive use of antibiotics needs to be reduced. Regarding the economics of public goods, antibiotics are thus an “impure” good as they have both private and public value (Smale *et al.*, 2004). When farmers use antibiotics, they do it for a private purpose: to prevent the development of BRD or to heal the weanlings. They expect the antibiotic treatment to be efficient and to generate profit in the short-term. But at the same time, as farmers use antibiotics, they are also eroding future antibiotic efficiency. Indeed, antibiotic use generates antibiotic resistance in the treated animal, on the farm and on a larger scale. Thus antibiotic resistance and antibiotic use have a public value, the insurance for future generations to have a useful and protective tool for managing animal and human health (Smale *et al.*, 2004). Regarding the issue of antibiotic use, fatteners thus face a social dilemma. Their personal interest is opposed to the collective interest (Abele *et al.*, 2010).

Figure 3: Principal strategies in medical control of BRD linked to the vertical integration in the young beef bull sector (source: author's elaboration)

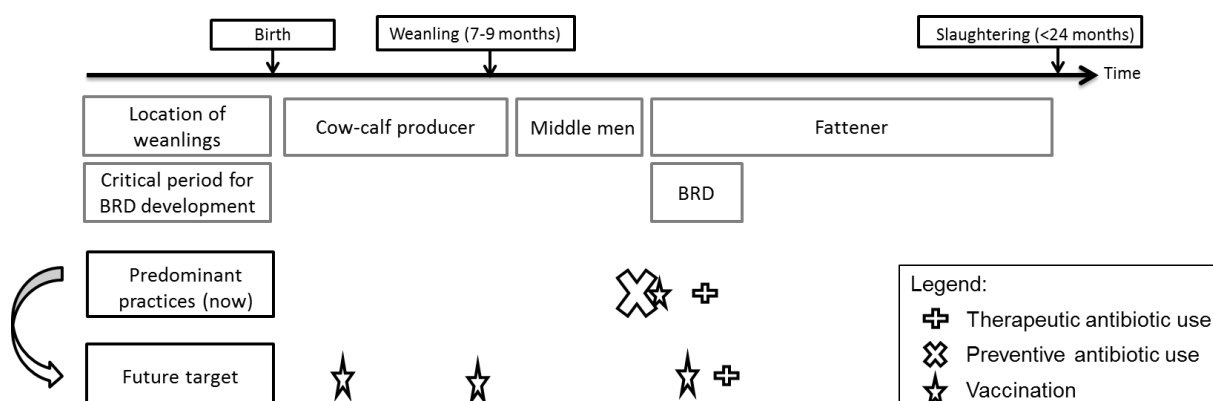


Table 7 shows that the quality attributes of weanling batches are intrinsically linked to the vertical integration pattern considered. Zootechnical batch characteristics might vary regardless of this vertical integration pattern. Conversely, logistical, and health characteristics are more strongly impacted in the case of high or low levels of vertical integration. The most efficient situation is one in which no transfer exists and the weanlings are fattened in the cow-calf producing farm (Figure 2, line ①). However, if this is not possible (limited size of the farm, limited animal feed producing capacities, geographic area, etc.), the second best option is the one involving direct transfers from the cow-calf producer to the fattener (Figure 2, line ②).

As the quality attributes of weanling batches influence the level of BRD risk and the possible measures required to prevent BRD, the level of vertical integration also indirectly influences the level of BRD risk and the choice of medical preventive measures (Table 7). The quality of weanling batches is globally improved as vertical integration increases. The risk of BRD therefore decreases as vertical integration increases, which makes the systematic and preventive use of antibiotics less necessary.

Table 7: Quality attributes of weanling batches and their effects on BRD risk and the systematic preventive use of antibiotics depending on vertical integration patterns (source: authors' elaboration)

	<i>Spot market</i>	<i>Oral commitment (direct) to farmer</i>	<i>Oral commitment to middlemen</i>	<i>Written contract</i>	<i>Vertical integration (cow-calf producer and fattener)</i>
<i>Quality attributes of weanling batches</i>					
Zootechnical characteristics	Medium or Good				
Logistical characteristics	Bad	Good	Bad or medium		Very good
Health characteristics	Bad	Medium to good	Bad or medium		Very good
<i>Consequences of quality attributes on BRD risk and systematic, preventive use of antibiotics</i>					
BRD Risk	Very high	Medium to small	Medium to high		Small
Systematic and preventive antibiotic use	Very likely	Unlikely	Likely		Very unlikely

In addition, as the level of vertical integration increases, the good transmission of information between stakeholders also increases. This in turn increases the likelihood of valuation and the implementation of good vaccine protocols to protect weanlings at the beginning of the fattening period. The most integrated system (Figure 2, line ①) is again the best system for information transmission as the same person is usually doing the cow-calf producing and the fattening phases. This is an additional element in the case of a high level of vertical integration that allows the reduction of systematic and preventive antibiotic use. However the best two vertical integration patterns, when considering the reduction of systematic and preventive antibiotic use, (Figure 2 line ①: perfect integration, or Figure 2 line ②: direct weanlings' transfer) are not often observed in the field because of the complexity of the sector, and because of the geographic distribution of production, which physically separates the upstream and downstream portions of the sector.

5. Discussion and conclusion

We describe here the context and reasons for the existence of multiple vertical integration patterns in the mature French young beef bull sector. Our analysis shows that cow-calf producers and fatteners face different transaction costs, which explains the choice of low vertical integration for cow-calf producers and more diverse forms of vertical integration, ranging from spot market to perfect vertical integration, for fatteners. We also show that the

level of vertical organisation has a direct influence on BRD risks and antibiotic use at the beginning of the fattening period. From a technical point of view, to diminish the risk of BRD and at the same time, the systematic and preventive use of antibiotics, one should implement early vaccination, reduce animal mixing, and reduce the length of transfers (Figure 3). From an economic point of view, this improvement will be linked to fewer transaction costs and a more vertically coordinated governance. This tends to confirm an empirical study by Paulraj *et al.* (2008), which showed a positive correlation between good information exchange and performance. However, hypothesis we built based on the interviews should be further tested on larger scale.

Our findings are coherent with the economics literature concerning the influence of transaction costs on vertical governance. More precisely, as reported by Meuwissen *et al.* (2001), we found that the greatest risks perceived by farmers are linked to input and output prices, even if the variations differ considerably between individuals (Meuwissen *et al.*, 2001). The complexity of the weanlings' market and the orientation of cow-calf producers toward spot markets accords with empirical studies (Coronado *et al.*, 2010). Cow-calf producers are not restrained by long-term contractual agreements. This enables them to sell weanlings through numerous marketing channels and to mitigate market risks (Chen *et al.*, 2004). The behavioural uncertainty of cow-calf producers might also have negative effects on trust, which can be a crucial element when developing long-term relationships (Geyskens *et al.*, 1998).

The lack of information transmission between stakeholders in the supply chain, and the absence of price premiums for quality do not encourage farmers to improve their quality and investment. Product quality is either poorly defined or neglected in the transactions. This is especially important as the demand broadcast by fatteners does not encourage an improvement of weanling quality upstream in the sector. As a consequence, the cow-calf producers compete on volumes and prices, and less coordinated patterns are logically preferred (Boger, 2001). Good collaborative transmission of information is however less likely with short-term relationships (Paulraj *et al.*, 2008). Improving the system of information transmission in the young beef bull sector thus could be an important lever both to improve economic performance and to meet public health requirements.

In the observed vertical governance in the young beef bull sector, there are high risks of BRD at the beginning of the fattening period, often leading to a systematic and preventive use of antibiotics by fatteners. However, this vertical integration and technical practices could be

threatened by an institutional risk. Indeed, the French Ministry of Agriculture has already introduced a national plan known as “EcoAntibio”. During the first phase (2012-2017), among other things, the French government enforced a stronger regulation of antibiotic use to accompany antibiotic reduction. During the second phase of the plan (2017-2021), an additional regulation could possibly ban systematic and preventive antibiotic use, which would threaten fattener. Indeed, they use antibiotics in a systematic and preventive way to protect weanlings against the very likely risk of BRD linked to the transfers and mixing of upstream in the sector. In the present system, a ban on preventive and systematic antibiotic use could seriously burden the fatteners’ incomes and the whole vertical governance in general. In the case of such a regulation, this vertical governance needs to be rethought by the entire sector. For instance, the improvement of information regarding batch quality could be very important and linked to price premiums, for which the fatteners could agree to pay. Having better information about batch quality could also reduce the risk and uncertainty linked to health issues.

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Appendix 1: Material details on interviewees and field observations

Table 8: Semi-structured interviews and field observations

<i>Profession</i>	<i>Number, of interviews / field observations</i>	<i>Depending institution</i>
Semi-structured interviews		
Cow-calf producer***	7	Cooperative and independent
Breeder-fattener***	12	Cooperative and independent
Fattener***	5	Cooperative and independent
Middlemen***	10	Cooperative and independent
Farm advisors*	4	Cooperative
Veterinarians***	8	Cooperative and liberal
Middlemen superiors*	3	POC and PONC
Chamber of Agriculture*	1	-
Meat producers' Union*	1	-
Slaughterhouse director*	1	-
Senior Official**	2	French Ministry of Agriculture
Field observations		
Specialized fattening units*	4 (one day)	-
Livestock Market***	2 (one day each)	-
Sorting centre*	2 (2 hours each)	Cooperative

*Regions considered: *Western France; ** National; ***Western France and Central France*

Appendix 2: Influence of observed transaction costs on the most commonly observed vertical integration governance

Table 9: Observed transaction costs of cow-calf producers on the most commonly observed vertical integration governance

<i>Transaction costs observed (Cow-calf producers)</i>	<i>Influence of observed transaction costs on levels of vertical integration*</i>	<i>Most commonly observed vertical integration patterns and associated transaction costs</i>	
		<i>Spot market</i>	<i>Oral commitment (direct) to farmer</i>
Human specific assets	0	All levels of education and experience	
Physical specific assets	0	Few investments or higher investments	
Geographic specificity	0	Central France and Western France	Western France
Temporal specificity	0	Very low	
Dedicated assets	1 ⁺	Very low	Moderate (e.g. vaccination)
Uncertainty - Risk	1 ⁺	Moderate	
Complexity	2 ⁻	Very high	High
Asymmetry of information	0	High	Reduced to a minimum

** 0: Ceteris paribus, no influence on vertical governance; 1: Ceteris paribus, influence (⁺positive or ⁻negative) on vertical governance depending on individual characteristics; 2: Ceteris paribus, influence (⁺positive or ⁻negative) on vertical governance*

Table 10: Observed transaction costs of fatteners on the most commonly observed vertical integration governance

Transaction costs observed (Fatteners)	Influence of observed transaction costs on levels of vertical integration*	Most commonly observed vertical integration patterns and associated transaction costs				
		Spot market	Oral commitment (direct) to farmer	Oral commitment to middlemen	Written contract	Integration
Human specific assets	0	All levels of education and experience				
Physical specific assets	0	Little or higher investments	Little or higher investments	Little or higher investments	High investments	Little or higher investments
Geographic specificity	0	Central France and Western France	Western France	Central France and Western France	Central France and Western France	Central France and Western France
Temporal specificity	1 ⁺	Low	Low to moderate			Low
Dedicated assets	1 ⁺	High				Moderate
Uncertainty - Risk	1 ⁺	Moderate (fattening, additional activity)	High (fattening, additional but important activity)		High (fattening, major activity)	High (no plural activity)
Complexity	1 ⁺	Moderate				
Asymmetry of information	2 ⁻	high	Very Low	Low to moderate	Low to moderate	Null

* 0: *Ceteris paribus*, no influence on vertical governance; 1: *Ceteris paribus*, influence (+positive or -negative) on vertical governance depending on individual characteristics; 2: *Ceteris paribus*, influence (+positive or -negative) on vertical governance

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