Major or minor? The EU food animal antibiotic policy and the varied use

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Abstract

Purpose – Limiting the use of antibiotics in food animals is a cornerstone of contemporary EU policy. Despite that marketing of antibiotics for growth promotion and nutrition has been banned since 2006, the use is still high and varied. This paper aims to investigate the forces behind the different usage patterns in Italy, with one of the EU's most extensive use of antibiotics in animals, versus Sweden, with the union's most restricted use, including how these usage patterns are related to EU and national policies.

Design/methodology/approach – The industrial network approach/the 4R resources interaction model is adopted to investigate the major forces behind the different antibiotic usage patterns. Furthermore, the study relies on the notion of three main characteristics related to the use of a resource activated in several user settings (Håkansson and Waluszewski, 2008, pp. 20–22). The paper investigates the Swedish and the Italian using settings, with a minimised, respectively, extensive usage of antibiotics. The study is exploratory in nature and based on qualitative data collected through a combination of primary and secondary sources.

Findings – The paper underlines the importance of integrating forces for policy to succeed in attempts to reduce the use of a particular resource. It reveals that Sweden's radically reduced use was based on great awareness, close interactions between animal-based food producers and policy – and that integrating forces were supported by an era of state-protected food production, with promising ability to distribute the cost of change. The Italian characteristics hindering the integration of forces mounting for reduced use were restricted awareness, top-down business and policy interactions – and a great awareness about the difficulties of distributing the cost of change.

Originality/value – The study deals with the analysis of forces affecting the different usage of antibiotics within two EU settings. The investigation, based on the industrial network approach's notion of connectivity of economic resources, that is, of exchange having a content and substance beyond discrete transactions, reveals how indirect related contextual forces, neglected by policy, have an important influence on the ability to achieve change, in this case of antibiotics usage patterns.

Keywords Policy, Antibiotics, AMR, Usage patterns, Food animals, Cost of change

Paper type Research paper

1. Introduction

> Limiting the use of antimicrobials must be the priority. (EU Commissioner for Health and Food Safety, Stella Kyriakides, 2022) [1].

The Commissioner for Health and Food Safety, Stella Kyriakides, underlined the importance of limiting the use of antimicrobials when the new EU regulation on veterinary medical products came into force on 22 January 2022 [2].

Overuse and misuse of antibiotics, estimated to cause 1.27 million deaths per year [3], are perhaps most extensive in the animal-based food setting. About one-third of the world's use of antibiotics goes to humans, while two-thirds are estimated to be used in animal husbandry, mostly to stimulate animal growth and to combat production-related diseases (Van Boeckel *et al.*, 2015, 2017; Kirchhelle, 2018; Kahn, 2016).

The 2022 EU regulation introduced a general principle, stating that antibiotics cannot be used preventatively as compensation for investments in precautionary animal health, hygiene and welfare [4].

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If the ban on "preventative use" is going to be realised, it implies that large parts of the EU's animal-based food industry must go through an extensive systemic shift. Investments must be made in precautionary animal health, biosecurity and animal welfare. As expressed by the European Public Health Alliance (Nunan, 2022, p. 18):

> This is an important article since it is effectively saying that if animals are managed in ways that cause them to fall ill routinely, then antimicrobials cannot be used to resolve this problem (Nunan, 2022, p. 18).

It is too early to judge whether the new regulation will force European animal-based food companies in general to engage in changes that allow a radical reduction in the use of antibiotics. Instead, this paper focuses on the contemporary use in two countries, Sweden and Italy. The first is chosen due to that it represents what the EU regulation is aimed to achieve but which is still restricted to the Nordic setting: minimised use of antibiotics. The second due to that it, despite that the EU already in 2006 banned antibiotics for growth promotion and nutrition (EU, 2005, IP/05/1687), represents one of the highest usage levels within the EU (ESVAC/EMA, 2021; Nunan, 2022). In fact, the Italian use is about 20 times higher than the Swedish, which represents the lowest use in the EU [5]. The usage of antibiotics in the two countries appears rather contradictory and leads to an intriguing overall question:

> How is it that the usage of antibiotics for food animals differs so much in two EU settings, despite working under the same EU regulations?

Based on the above introduction, the overall *aim* of this paper is to outline the forces, that is, ideas and activated structures (Håkansson and Waluszewski, 2007a) behind Italy's extensive and Sweden's minimised use, including the role of the national and EU policies. The following *research question* (RQ) can be formulated:

RQ. What main forces are behind the different antibiotic usage in the Italian, respectively, the Swedish animal-based food settings?

The RQ implies:

1 empirical investigations concerning the forces behind the still extensive use in the internationally famous and export-oriented Italian animal-based food setting, as well as the "minimised" Swedish use, a change initiated more than a decade before the country became an EU member; and
2 theoretical considerations of what kind of approach, based on what underpinnings, is fruitful to use to achieve detailed pictures of the forces related to the use of a particular resource, as well as of policy attempts to change this.

About the latter point, which is our initial theoretical consideration, it is appropriate to underline that the varied use of antibiotics indicates that fulfilling the goal of global policy is far more complicated than what is appointed as key policy measures: to encourage individuals, individual businesses and organisations to change behaviour to reduce use of antibiotics (Chandler, 2019; Kirchhelle, 2018; Waluszewski *et al.*, 2021). Despite underlining the complexity related to antibiotic usage patterns and antibiotic resistance, the global policy measures seem to be relying on assumptions of independent actors, able to change without clashes with social and material investments in place (Chandler, 2019; Rider and Waluszewski, 2015).

The difficulties of affecting usage patterns underline the importance of recognising the embeddedness of antibiotics, or, as labelled by Chandler (2019), the "antibiotic infrastructure". That is the social and material resources that are directly and indirectly related to the use in different settings, and that are affected, or expected to be affected, by a radically reduced use. Our theoretical point of departure, chosen to catch the forces related to this "infrastructure", is the industrial network approach, and its basic notion of resource heterogeneity, which implies economic connectivity of resources in use (Håkansson and Snehota, 2024). Put shortly, we suppose, paraphrasing Håkansson and Snehota (1989, 2017), that "no antibiotic user is an island".

The paper is structured as follows. In the next section, we present our research design, which includes in more detail the theoretical and methodological approach. Thereafter follows an empirical background of the role of antibiotics as an economic resource in animal-based food production, including policy's shift from supporting the use to trying to limit it. The next sections focus on the Swedish and Italian pig meat-based food setting, an application area that, along with poultry, traditionally represents the largest use of antibiotics in food animals (FAO, 2020). The aim is not to make a traditional comparative study but rather to investigate the forces behind the different usage patterns in those focal settings. Thereafter follows a discussion of the empirical results, conclusions and implications of the study.

2. Research design

At a first glance, EU policy, which has adopted the "One Health" approach to antibiotic resistance, launched by the tripartite alliance of the World Health Organisation (WHO) [6], Food and Agriculture Organisation (FAO) [7], the World Organisation for Animal Health (OIE) [8], gives an impression of recognising the multiple interdependencies behind antibiotic usage patterns. The concept of "One Health" was coined to lift forward the interconnections between human and animal health, and agricultural and environmental needs. The principle recognises, as expressed in the EU One Health Plan against AMR, *"that human and animal health are interconnected, that diseases are transmitted from humans to animals and* vice versa *and must therefore be tackled in both"* [9].

The "One Health" approach raises expectations of policy analysis recognising the economic connectivity behind the use of antibiotics. However, such underpinnings are surprisingly absent, in favour of a focus on individuals and individual businesses and organisations (Chandler, 2019; Waluszewski *et al.*, 2021; Baraldi and Wagrell, 2022). Instead, the main measure is to change the behaviour of individuals and individual organisations through the following activities:

- spreading knowledge and awareness;
- supporting monitoring of use; and
- supporting the implementation of national standards.

In relation to the use of antibiotics in animals, a rather narrow spectrum of individuals and individual organisations are addressed: those directly involved in animal husbandry and food production. The serious consequence is that the

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"antibiotic infrastructure" behind the contemporary usage patterns remains hidden (Kirchhelle, 2018; Chandler, 2019).

"Context matter" and is present in all change processes, but is largely absent in contemporary policy, summarises Hoholm and Araujo (2017, p. 119). A specific contextual challenge of investigating the forces behind different antibiotics usage patterns in the animal-based food setting is that the benefits and drawbacks of use appear in very different constellations of companies and organisations. Routine use of antibiotics has, for decades, created economic benefits in the animal-based food setting; to farming companies, processing firms, suppliers of drugs, feed, equipment and veterinary services, as well as to companies related to the retail industry and to consumers. Since its launch in the early 1950s, routine use of antibiotics for food animals was for many decades also largely supported by policy; in western as well as eastern economies (Kahn, 2016; Kirchhelle, 2018; Waluszewski, 2023).

The main drawbacks of the use, in terms of speeding up the bacteria mutation and selection processes, causing antibiotic resistance and loss of efficacy of antibiotics, were not seriously approached by global policy until the past decade of the 20th century. The life-threatening and economic burden of antibiotic resistance is mainly affecting organisations in the health-care setting and, furthermore, pharmaceutical businesses engaged in the development of new drugs (Kahn, 2016; Kirchhelle, 2018; Baraldi and Wagrell, 2022).

Hence, forces behind different usage patterns and how these have changed might appear both in close relation to and distantly from direct exchange between supplier and customers. However, the usage consequences, antibiotic resistance, do, to a large extent, appear distantly from the latter. That is, beyond the monetary deals made in direct business exchange (Håkansson and Olsen, 2015; Perna *et al.*, 2015; Baraldi and Lind, 2017; Håkansson and Snehota, 2024). To investigate such usage patterns and forces aimed to create change, it is necessary to incorporate, as underlined by Håkansson and Snehota (2024), direct *and* indirect interactions and relationships among different constellations of companies and organisations, and what happens within and between them. Below, we will present our theoretical and methodological approach more in detail.

2.1 Theoretical approach

It is the basic notion of resource heterogeneity that points to the importance of context and direct and indirect usage connectivity (Håkansson and Snehota, 1995, 2017; Araujo *et al.*, 1999; Gadde and Snehota, 2000; Håkansson and Waluszewski, 2002a, 2007b, 2008). Resource heterogeneity implies that interaction over time is a significant ingredient in attempts to develop resources and change resource interfaces, to create both efficiency and innovativeness (Håkansson and Waluszewski, 2002b, 2024). Hence, the use of resources is characterised by "multiple interdependencies" with "permeable and fuzzy boundaries" (Håkansson and Snehota, 2017, p. 17). Any force mounting for change of the use of a specific resource will be met by reactions; supporting or counteractive, depending on how the use, in what settings, for what purposes, is supposed to affect – and be affected by – related resources (Håkansson and Waluszewski, 2007a, 2008; Prenkert and Cantillon, 2008; Gadde and Snehota, 2000).

Furthermore, the use of a specific resource, taking place in direct and indirect combinations with other physical and social resources, by commercial, governmental and non-governmental actors, can be more or less fundamental in these different user systems. Exactly what consequences, for what specific resources, a changed use of an embedded resource will have, is more or less impossible to outline in advance (Håkansson and Waluszewski, 2002b, 2008; Perna *et al.*, 2015) and especially from a cost point of view (Waluszewski *et al.*, 2017b; Perna and Waluszewski, 2018).

Similar understanding of the systemic features of use and the complexity of changing user patterns are expressed in science and technology studies (STS) (Bijker, 1987; Jasanoff, 2004; Rider *et al.*, 2012), in heterodox economy studies (Lawson, 2005; Marglin, 2008; Fourcade *et al.*, 2015) and by scholars engaged in antimicrobials in society studies (Chandler, 2019; Kirchhelle, 2018).

More recently, a number of studies on the use of antibiotics and the multifaceted resistance challenge have been carried out in the industrial network research setting. What these studies have in common is the contextual interest, or, as put by Baraldi and Wagrell (2022, p. 377), how antibiotics are "*embedded in complex socio-technical networks where they are connected and interact with several other resources*". To catch network complications related to the change in the use, production and development of antibiotics, several of these studies used the so-called *4R resource interaction model* (Håkansson and Waluszewski, 2002a, Prenkert *et al.*, 2022; Baraldi and Wagrell, 2022; Baraldi *et al.*, 2022; Halinen *et al.*, 2022; Ciabuschi *et al.*, 2021; Kronlid and Baraldi, 2020; Baraldi *et al.*, 2016; Waluszewski *et al.*, 2018, 2021).

The contextual importance disqualifies the individual decision-maker, the single business and organisation and the single dyad between businesses and organisations as focal research objects (Håkansson and Snehota, 2024). In this study, the focal research object is the forces; ideas and activated structures, behind the different usage patterns of antibiotics in two constellations of businesses and organisations: the Italian respective and the Swedish pig meat-based food settings.

To catch these forces, we used the *4R model* (Håkansson and Waluszewski, 2002b, pp. 72–75) as the analytical framework. The 4R model is, like all IMP research models, phenomenon-driven, that is, based on the notion of the exchange of heterogeneous resources, having a content and a substance beyond discrete transactions (Waluszewski *et al.*, 2017a, 2017b). The 4R model was developed to allow the investigation of interactions affecting the content of exchange regardless if represented by relationships or not (Håkansson and Waluszewski, 2002b). For example, interactions driven by both close and distantly related business actors, non-governmental organisations (NGOs) and/or policy bodies. Put shortly, the 4R model allows the investigation of how idea structures and activated structures interact in relation to four types of resources: two mainly social (business units and business relationships) and two mainly material (production facilities and products) (Håkansson and Waluszewski, 2002a; Waluszewski *et al.*, 2017a). Hence, we used the 4R model to catch forces influencing the different usage patterns in the Italian and Swedish settings; the role of policy included.

Furthermore, we used the notion of three main characteristics related to the use of a resource *activated in several* *user settings* (Håkansson and Waluszewski, 2008, pp. 20–22) to highlight forces aimed at reducing use. While the importance of the developing setting, and also the producing settings are recognised in contemporary policy – although resource interdependencies still tend to be neglected – using interdependencies are rarely recognised (Håkansson and Waluszewski, 2008). This is despite that a changed use of a resource, especially if embedded into several using systems, might have severe consequences for a number of existing investments – in positive or negative ways [10].

The three main aspects can be expressed as follows (Håkansson and Waluszewski, 2008, pp. 20–22):

1. Are forces aimed to reduce the use of a particular resource related, that is, are these integrated into direct and indirect related using settings?
2. Are forces aimed to reduce the use of a particular distributed to direct and indirect connected interfaces?
3. Are forces aimed to reduce the use of a particular resulting in adaptations and knowledge development?

The analytical framework presented in Table 1 guided the investigation of forces behind the different antibiotic usage patterns in our two focal using settings. Hence, we used the analytical framework in line with the ambition of the industrial network research tradition; to achieve more detailed pictures of our focal research object (Waluszewski *et al.*, 2017a) (Table 1).

2.2 Methodology

To investigate the research question concerning the forces behind Italy's extensive and Sweden's minimised use, we used the above presented framework as guideline in a case study, which is considered useful for investigating complex, evolutionary phenomena with uncertain boundaries (Håkansson and IMP Project Group, 1982; Yin, 2014; Voss *et al.*, 2002; Eisenhardt, 1989). Moreover, case studies focusing on connectively have been extensively used in the IMP setting, to investigate content and consequences of exchange of heterogeneous resources; the role of interactions and relationships included (Håkansson and IMP Project Group, 1982; Håkansson and Snehota, 1995; Waluszewski *et al.*, 2017a).

The data collection is based on a combination of methods. Interviews were used to collect data on the direct and indirect use of antibiotics in pig meat-based food. In-depth interviews (Kvale, 1994; Legard *et al.*, 2003) were carried out, with representatives of pig meat farms, farmers' associations, slaughterers/food processing firms, the retail industry and consumer organisations, scientists specialised in veterinary, microbiology, biology, medicine and with policymakers, government agencies and NGOs.

All interviews, which lasted from about 45 min to half-day site visits, were made with semi-structured guides, focusing on the role of antibiotics and resistance in the settings represented by the specific respondents. That is, specific themes (Kvale, 1994; Legard *et al.*, 2003) were prepared and provided guidance during the interview, leaving space for discussions and encouraging the informants to add further information (Johnsen and Ford, 2007). Sixty personal interviews, including site visits, were carried out focusing on the use of antibiotics and attempts to create change and antibiotic resistance, in the different empirical settings in general and for the specific respondents.

Secondary data, such as published research studies and governmental and non-governmental business reports, were used to gain insights into the global animal antimicrobial/antibiotic resistance challenge. Antibacterial studies and animal health studies, as well as studies in the history of medicine, history of technology, sociology and industrial network studies, were used to gain insight into the use of antibiotics in the animal-based food setting over time, and its economic and societal consequences. Governmental and NGO reports were consulted to gather data on global animal antibiotic use and resistance patterns.

3. Background: a long-time policy supported use of antibiotics in animals

For about a half century, policies in western and former eastern economies supported the embedding of antibiotics, as part of the everyday feeding routines of animals for food production (Thoms, 2012; Kahn, 2016; Kirchhelle, 2018). The common, initial reaction to the launch of antibiotics in animals, taking place in the late 1940s and early 1950s, was more directed to the advantages than drawbacks, despite the fact that the intrinsic characteristics of bacterial mutation were already known (Wise, 2007; Kirchhelle, 2018). Trust in the industry's ability to continuously present new types of antibiotics overshadowed the resistance fear (Gradmann, 2016).

When it became evident that a low, everyday dose through feed and water increased the growth of the animals, especially pigs and poultry (Stokstad *et al.*, 1949), antibiotics became used as a production economic resource. Besides being a groundbreaking veterinary-medical resource (Thoms, 2012; Kahn, 2016; Kirchhelle, 2018), antibiotics became both a policy and industry mean to rationalise animal-based food production and to increase the supply of affordable food

Table 1 Analysis of forces behind antibiotic usage patterns, based on Håkansson and Waluszewski (2008, pp. 20–22)

Usage interfaces with:	*Are forces aimed to create reduced use integrated into related using settings?*	*Are forces aimed to reduce use distributed to direct and indirect connected interfaces?*	*Are forces aimed to reduce use resulting in adaptations and knowledge development?*
Products			
Facilities			
Organisational units			
Relationships			

Source: Authors' own work

(Kirchhelle, 2018; Begemann *et al.*, 2018). As expressed by Kirchhelle (2018, p. 5):

> Spreading antibiotic infrastructures initially elicited few concerns. During the 1940s and 1950s, the vast majority of US and Soviet commentators celebrated agricultural antibiotics as a sound way to enhance animal productivity and preserve food.

Routine use of antibiotics for growth and nutrition became the short track to decreased costs and increased output. It allowed increased numbers of animals in the same space, reduced manual work with each animal, shortened the weaning period, shortened the production cycle and allowed increased transport of animals (Thoms, 2012; Kahn, 2016; Kirchhelle, 2018). The possibilities attracted attention in both academic and industrial research, and the 1960s saw a boom in publications on antibiotics as feed additives in animal-based food production (Thoms, 2012). The "modern" antibiotic-based animal-based food production allowed, as Thoms (2012, p. 182) puts it, "an intensification of farming and animal husbandry that had been unthinkable before". It was not only the animal-based food producers who benefitted economically (given that the cost of resistance was neglected) from the antibiotic-based production regime but also veterinaries, the pharmaceutical industry, the retail industry and the consumers.

3.1 Awakening environmental concerns

At least in western economies, the 1960's awakening environmental debate directed attention to the consequence of chemicals and drugs in agriculture. With Rachel Carson's (1962) *Silent Spring* and Ruth Harrison's (1964) *Animal Machines* as wake up calls, consequences of compensating investments in animal health with antibiotics gained attention.

In the UK, the environmental debate coincided with increasing veterinary reports of outbreaks of resistant bacterial infections, affecting both animals and humans, creating an intense public debate. The UK government became more or less forced to initiate what later on was labelled the "Swann Committee" (The Joint Committee on the use of Antibiotics in Animal Husbandry and Veterinary Medicine), investigating the use of antibiotics and resistance outbreaks in human health care and animal production (Kahn, 2016; Begemann *et al.*, 2018; Kirchhelle, 2018).

The "Swann report", delivered in 1969, became something of the first internationally recognised policy advice on the use of antibiotics in animals. However, the message from the Swann report was not clear-cut. On the one hand, it confirmed that antibiotics for growth promotion drive resistance, thus threatening human and animal health (Wise, 2007; Kahn, 2016; Kirchhelle, 2018; Begemann *et al.*, 2018). On the other hand, it recognised the economic importance of antibiotics in animal-based food production and suggested that certain antibiotics still should be accepted for routine use in feed (such as macrolides), while others should be reserved for medical purposes (such as penicillin and tetracycline) (Swann *et al.*, 1969; Wise, 2007; Kahn, 2016; Kirchhelle, 2018). However, a back door to regular use of these drugs was created. Although penicillin and tetracycline should be phased out as growth promoters and reserved for medical use, the Swann suggestion was that they could still be used for group treatments of animals, if they were provided by veterinarians for "disease prevention" (Thoms, 2012; Kahn, 2016; Begemann *et al.*, 2018; Kirchhelle, 2018).

The Swann report's solution to treat use restriction as a matter of choice between antibiotics for growth/nutrition or for medical treatment can also be traced to the first European Economic Community (EEC) regulation on feeding stuffs of 23 November 1970 (70/524/EEC) [11]. Although revised several times, the distinction between antibiotics for nutrition, as a low-dose ingredient in animal feed, and antibiotics for veterinary-medical purposes, given in larger doses, remained a cornerstone in the EEC and later in EU regulations until the very last year of the 20th century. Even if the EU started to ban certain antibiotics as ingredients in animal feed in 1998 (triggered among others by the Swedish engagement, which we discuss below), it was not until 2006 that all use of antibiotics for nutrition and growth promotion was finally banned (Kahn, 2016; Nordeus, 2022).

3.2 A "Dry pipeline" mounting for usage change

In the new millennium, it was obvious that the "dry pipeline" characterising the antibiotic development period since the late 1980s, along with growing bacterial treatment failures, increasing health-care costs and increasing mortality, caused a global health threat (Baraldi *et al.*, 2016; Kirchhelle, 2018; Chandler, 2019). There has been a dearth of truly innovative antibiotics since the 1980s due to both scientific challenges and a lack of financial incentives for drug developers. If some new products might be launched, the future use of these must be restricted to protect their efficacy (Baraldi *et al.*, 2022; Waluszewski *et al.*, 2018). To restrain the overuse of antibiotics stabilised as a global policy goal (Kirchhelle, 2018; Chandler, 2019) [12].

4. Policy and the Swedish "minimised" use of antibiotics

4.1 Did the European Union act quickly or slowly?

From the perspective of the EU Commission, the EU was quick to act against antibiotic resistance/AMR:

> The EU was quick to recognise the importance of tackling AMR.

This statement of the EU Commission was made in June 2017, when the EU launched its One Health Action Plan referring to its 2001 adoption of a strategy against AMR [13]. Three years later, the EU Commission launched the "Farm to Fork" strategy [14], with "sustainable food systems" in the EU as its overall goal. To combat antibiotic resistance, the goal was to reduce the overall sales of antibiotics in food animals (aquaculture included) with a 50% reduction by 2030 [15]. Along with these strategies, the updated EU regulation on veterinary medical products that came into force in January 2022 was appointed "a cornerstone" to support the goals of the One Health Action plan and Farm to Fork strategy [16].

But, was the EU recognition quick? From the perspective of the Swedish actors engaged in getting rid of routine group treatment of animals with antibiotics, the EU's actions to reduce the use of antibiotics in food animals were not only very late but also counteractive.

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4.2 The European Union acts against the Swedish and world's first ban of antibiotics as growth promoters

It was in relation to Sweden's membership in 1995 that the EU reacted negatively towards the Swedish law that had been in force since January 1986, banning any use of antibiotics in animals that was not strictly medically motivated. That is, routine group treatment with antibiotics for growth promotion and nutrition was strictly forbidden. The message from the EU Commission was that Sweden had to adapt to the community regulation on feeding stuff, allowing certain antibiotics in feed for nutrition and growth [17].

After negotiations, Sweden managed to get a redemption until 31 December 1998 [18]. After that, the group of antibiotics allowed to use as additives in feed in the EU had to become legal also in Sweden (Nordeus, 2023).

However, the EU's reaction did not persuade the intercessors behind the Swedish engagement to get rid of routine group treatment of animals with antibiotics. In fact, since they took off in the early 1980s, the Swedish endeavours had a double mission: to develop measures able to compensate for routine group treatment of food animals with antibiotics and to mobilise national policy to get legal support for a systemic shift.

4.3 Changing a system and mobilising national policy support

It was not policy but the farmers themselves with some pioneering pig producers and concerned managers at the Swedish Farmers' Association in the foreground that triggered the Swedish engagement in getting rid of everyday use of antibiotics. While the engaged farmers were concerned about the long-term environmental effects, the representatives of the Swedish Farmers' Association were afraid of losing consumers' trust due to an intensive media debate on the use of chemicals in agriculture, including antibiotics in animals.

In Sweden, the 1960s environmental debate coincided with a late modernisation of agriculture, where family-owned small farms were rapidly transformed into larger units, based on labour-efficient production practices. Among both farmers themselves and the general public, there were doubts as to whether the industrialisation of agriculture had been driven too far (Martiin, 2015; Flygare and Isacson, 2011; Morell, 2011). The late 1960s and early 1970s saw an "environmental shift" (Larsson Heidenblad, 2021); environmental journalism was established on the media agenda, and recognised scientists and representatives for governmental organisations and NGOs regularly contributed to the debate (Larsson Heidenblad, 2021; Begemann *et al.*, 2018).

Although Sweden had adopted the Swann report's suggestion and reserved certain antibiotics for medical use, others recommended for feed, including mecadox, avoparcin and virginiamycin, were regular ingredients in purchased pig feed (Wierup, 2001). Antibiotic-free feed, necessary for the pioneering farmers engaged in finding methods that could compensate for routine use, was something they had to pay extra for.

Along with the search for methods that could compensate for routine use of antibiotics, intense discussions on how to act collectively were carried out in the Swedish Farmers' Association. A first step was taken in 1981 when a policy document suggesting a voluntary exclusion of antibiotics was presented. However, this did not satisfy the engaged pig meat farmers, who were convinced that a "one for all" solution was necessary to achieve a significant change, and furthermore, that the Swedish Farmers' Association had to take a stand and mount for a legal ban of antibiotics for growth promotion.

Sweden was not yet an EU member, and for decades, Swedish agriculture was state-protected, based on a self-sufficiency policy. The Swedish Farmers' Association represented individual farmers in negotiations of prices and subsidies. The Swedish Farmers' Association was also an influential industrial actor through majority ownership in a number of cooperatively owned companies, including businesses engaged in supplying feed, equipment, slaughter, processing and marketing of animal-based food (Flygare and Isacson, 2011; Nilsson and Lind, 2015). For the pioneering farmers and managers, it was important to mobilise this resourceful organisation to push for a legal ban on the routine use of antibiotics for growth and nutrition.

After intense discussions, in 1984, the Swedish Farmers' Association got the annual meeting's support to approach the government with suggestions of a legal ban on routine use of antibiotics for nutrition and growth promotion. A similar bill was presented by the closely related Centre Party (former Farmers' Party).

There were political, organisational and business voices heard against the bill. The Right-Wing party argued that the law was not necessary because the final food products did not include antibiotic residuals. The veterinary community was divided, where those against a ban feared negative effects on animal health and production economy. The toughest resistance was presented by representatives from the pharmaceutical industry who, in several cases, aggressively argued directly to the most engaged farmers, representatives for the Swedish Farmers' Association and politicians.

The ruling Social Democrats supported the bill, and in 1986, Sweden got the world's first law banning the use of antibiotics for nutrition and growth promotion in force (SFS, Swedish Code of Statutes, 1985, p. 295) [19]. A year later, the Social Democrats presented a bill of importance for the effects of the ban; a new animal welfare law, also triggered by an extensive media debate. The new law stipulated that *"animals shall in the future be protected not only from suffering but also from disease"* [20]. The bill was passed, and since 1987, several measures supporting the ban on the routine use of antibiotics became regulated in law: precautionary health measures, including space and material for animals to access natural behaviour.

With the ban in place, a systematic development process took off in the pig meat setting. The sudden stopping of routine antibiotic use revealed what it had covered up. Infectious diseases and mortality among piglets increased, leading to an increased prescription of antibiotics (Bengtsson and Wierup, 2006). A number of measures were undertaken involving almost all types of professions related to animal-based food production: the farmers themselves, veterinaries, researchers, suppliers of feed, equipment, transport and slaughter.

What later became labelled "biosecurity", and "precautionary health" became cornerstones to reach healthy animals and a low use of antibiotics (Backhans *et al.*, 2015; Magnusson *et al.*, 2019; Nordeus, 2023), the most important change was the batch-wise breeding process, with loose animals with access to straw, and with sanitary periods between each batch of piglets (for a detailed description of the changes undertaken, see Waluszewski *et al.*, 2021).

4.4 Mobilising the European Union support

The EU's approach to the Swedish ban on routine use of antibiotics for growth and nutrition, a few years exemption, triggered once again mobilisation efforts to convince policy, this time on the EU level. The EU had argued that if Sweden could not present scientific evidence for its ban, which was argued to be based on ethical reasons, the EU regulation allowing certain antibiotics for growth and nutrition had to be followed. Presenting such arguments became a main task for the Swedish engagement, with a number of representatives for the "Swedish model" involved: politicians, veterinaries, researchers and farmers. The Swedish Minister of Agriculture commissioned an inquiry aimed to serve as a suggestion for the EU to not only accept but also adopt the Swedish antibiotic strategy. The report was delivered in 1997 and based on data presented by the Board of Agriculture, the Swedish Veterinary Institute, the Food Safety Agency, the University of Agricultural Sciences, the Environmental Protection Agency and the Medical Products Agency among others (FAO, 2020; Nordeus, 2023). The report concluded that antibiotics in feed had short-term production economic benefits but long-term negative consequences in terms of resistance and deficient animal health (SOU; Government Offices of Sweden, 1997, p. 132).

Voices expressing similar critiques of routine use of antibiotics were expressed from a few other EU member states; Finland, Denmark and The Netherlands (Dibner and Richards, 2005; Nordeus, 2023). Despite heavy protests from the pharmaceutical industry and also from the EU's Scientific Committee on Animal Nutrition, the first EU ban on one type of antibiotic used for growth and nutrition, avoparcin, came into force in 1998 (Dibner and Richards, 2005; Kahn, 2016; Kirchhelle, 2018). In 1999, four other types of antibiotics for growth and nutrition were banned: tylosin, spiramycin, bacitracin and virginiamycin (Dibner and Richards, 2005). The EU's changing attitude implied that Sweden could hold on to its 1986 ban. More importantly, the long-term consequences of using antibiotics as a production economic resource had begun to be seriously considered in the union. As Kirchhelle (2018) summarise:

> Although European farmers retained access to higher-dosed therapeutic and prophylactic antibiotics via veterinary prescriptions and emergency spraying permits, the EU's precautionary bans marked a significant victory for antibiotic critics(Kirchhelle, 2018, p. 8).

4.5 The cost of change – Swedish "minimised use" against low-price antibiotic-based import

If the Swedish engagement to get rid of routine use of antibiotics for growth and nutrition was successful and eventually got support from EU policy, the cost of change was unevenly distributed. Entrance into the union meant an influx of low-price meat stemming from antibiotic-based production regimes. Swedish pig meat production was hit hard. In a few years, the production fell from about 4 to 2.6 million pigs per year [21]. About 80% of the Swedish pig meat farmers went out of business, above all small and medium-sized units.

It took almost 20 years before the retail industry became more or less forced to engage in lifting forward the restricted use of antibiotics behind Swedish animal-based food production. An intense debate took off in relation to the EU election in 2014, when the media directed attention to the overuse of antibiotics in European food production, with a special focus on Denmark. It was shown that about 90% of the pigs, and many people exposed to pigs in their work, were carrying the multi-resistant LA-MRSA bacteria, something that had caused a number of human deaths [22]. The Swedish minimised use of antibiotics was also presented, including the fact that outbreaks of LA-MRSA were rare exceptions.

An individual retailer in the ICA group decided to stop selling Danish pig meat, along with informing the customers of the minimised use of antibiotics in the Swedish food system. The dominating retail chains ICA, Coop and Axfood reacted rapidly and presented similar policies for animal welfare and the use of antibiotics. Along with the policies, the branding of "Swedish meat" was introduced, including consumer information about the production system behind it.

The attention to the connection between the use of antibiotics in animal-based food and antibiotic resistance caused a significant change. The productivity, measured in terms of pigs per sow, had stabilised at about the same level as the European average [23]. However, compensating routine use of antibiotics with investments in precautionary health, biosecurity and hygiene were more labour-intensive and less space-efficient. The cost of production, given that the cost of driving antibiotic resistance was not included, stabilised at about 10%–15% higher compared to the EU on average, resulting in higher consumer prices.

Despite this, the consumption pattern started to change in favour of "Swedish meat". After 30 years of struggling with measures compensating for regular group treatment with antibiotics, the pig meat producers were eventually rewarded economically.

5. Policy and the extensive Italian use of antibiotics

5.1 Antibiotics absent in the public debate

If the Swedish engagement for restricted use of antibiotics in animals was driven by farmers and farmers' cooperatives, which eventually had to struggle to get EU policy on their side, the Italian situation is, in many aspects, the opposite. Put briefly, the media debate had been almost absent, and the engagement among farmers and industry was generally restricted, besides a rather small group of organic farmers. Instead, it was basically EU and WHO policy, along with concerned researchers, that pushed national Italian policy to engage in activities aimed at reducing the use of antibiotics for animals.

In contrast to Sweden, where the 1960s and 1970s social movement had environmental issues at the top of the agenda, that time Italian social engagement was mainly focused on labour justice (Armiero and Hall, 2010; Bertuzzi, 2019). Environmental concerns were considered as tasks for the prioritised classes. Use of chemicals and drugs in agriculture

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moved down in priority issues in the general debate (Waluszewski *et al.*, 2021).

The public debate continued to be poor despite the country being recurrently placed among the most extensive users in the ESVAC/EMA reports on veterinary antimicrobial consumption. Although the use decreased from 322 mg/PCU in 2015 (ESVAC/EMA 2017) to 181.8 mg/PCU in 2020 (ESVAC/EMA, 2021), Italy is still among the top three investigated countries.

Not even the fact that Italy is one of the EU countries with the highest burden of antibiotic resistance has put antibiotic resistance/AMR on the public debate agenda, the resistance situation was characterised as follows in the ECDC Italian country report ECDC (2018, p. 10):

> Seen from a European perspective, the present AMR situation in Italy is worse than in many other member states.

The fact that awareness among the general public is weak is also revealed in the few research studies touching on these issues, pointing to a lack of general knowledge about resistance and how to combat it (Napolitano *et al.*, 2013; Di Gennaro *et al.*, 2020). Still, it is too early to outline whether the aftermath of the Covid-19 pandemic will create a significant change, but the need for treatment of secondary bacterial infections has brought some media attention to the importance of the efficacy of antibiotics.

Notwithstanding that in 2006, the EU banned all marketing and for "growth promotion" and "nutrition", it took more than a decade before Italy got its first National Plan to combat overuse in the food animal setting. One of the main measures triggered by the EU pressure was the so-called "e-prescription" system [24] launched in 2017, with the aim of reducing the prescriptions by 30%. The e-prescription was introduced after trials in three Italian regions with extensive pig meat farming (Lombardia, Abruzzo and Marche Region). The development of the system involved several actors related to the supply and use of antibiotics in animals; besides initiating policy, it also affected veterinarians, businesses selling veterinary medicinal products, feed business operators, farmers and larger owners of animal-based food production. The e-prescription system was a pivoting point for the creation of the Central Drug Traceability Data Bank and the National Information System for pharma surveillance to contribute to adding data for traceability of veterinary medicines and medicated feed to the Ministry of Health. 2017 also saw the launch of Italy's first "National Plan to Combat Antibiotic Resistance" (PNCAR), triggered by WHO's global action plan on antimicrobial resistance (Cangini *et al.*, 2021), presented in May 2015 at the World Health Assembly [25]. In accordance with the WHO Resolution WHA 68.7, all member states, including Italy, agreed on developing national action plans by May 2017. In 2020, the PNCAR plan was followed up by guidelines specifically directed to the use of antibiotics in animals.

However, the Italian national policy's response to the pressure from the EU and WHO did not include any legal regulation concerning the use of antibiotics as "prophylaxis therapy", that is, group treatment of whole groups of animals to prevent disease. Instead, it relied on monitoring veterinary prescriptions and on spreading awareness about "best practises" in terms of how its use can be restricted.

Nevertheless, there are still Italian policy actors who try to keep away from the still extensive use of antibiotics for animals. For example, when the Italian Ministry of Health (2021) arranged a webinar on the theme "Antimicrobial resistance, the One Health approach at the time of the COVID-19 pandemic" in 2021, the General Director of the Directorate of Animal Health and Veterinary Drugs drew attention to the use of antibiotics in animals having been reduced but avoided discussing the fact that the Italian user level is still one of the highest in the EU:

> [...]In the veterinary field, both the use of drugs and the prescription of antimicrobial drugs have been reduced, thanks also to several tools we have been able to put in place. The latest findings obtained in the context of the tripartite alliance, OECD, FAO and OIE, comfort us from this point of view [26].

How Italy will react to the new EU regulation on veterinary medical products that came into force on January 2022 [27] is still an open question, but without a doubt, the general principle of banning preventative use as compensation for investments in precautionary animal health, hygiene and welfare, implies that significant systemic changes must be undertaken. The contemporary system will be presented below, but first, we reflect on another EU regulation that was rapidly adopted in the Italian pig meat-based food setting.

If it is just recently that Italy has started to respond to pressure from the EU and transnational policy aimed to restrict the use of antibiotics in the food animal setting, another EU regulation was met with swift adoption: the protection of so-called "original food product", "Italian cuisine" or "Italian food". Spread by the Italian diaspora and recognised worldwide, the characteristics of different regional and national food products became important brands for the Italian food industry and policy to relate to.

According to brand researchers, Italian food products have been associated with such unique qualities that the origin in itself functions is a kind of quality guarantee (Ricci *et al.*, 2018; Temperini *et al.*, 2016). Both national and EU policies also actively supported the protection of Italian food products.

Already in 1992, the EU engaged in protecting original food products through the adoption of the Reg. (EEC) no. 2081/92; the first attempt of the EU commission to regulate and harmonise "Geographical Indications and Designations of Origin of Agri-food Products". In this regulation, the definitions of Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI) appeared for the first time. Some of these included product specifications of the registered product [28].

Since 2012, Italian pig meat-based food has been rewarded with the EU logos "Protected Designation of Origin" (PDO) and "Protected Geographical Indication" (PGI). At the national level, products with specific regional characteristics can be protected under logos such as "Qualità Alto Adige". The most famous Italian pig meat-based product, prosciutto, has been protected by the logo "The Prosciutto di Parma PDO" and the "Prosciutto San Daniele PDO" (Arfini and Capelli, 2009; Ricci *et al.*, 2018).

However, neither the EU nor the national logo touched on the role of antibiotics in food animals. In spite of the overarching goal to guarantee high standards in terms of product quality (art. 46, Regulation (EU) n. 1151/2012); the

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issue of protecting humans and animals from antibiotic resistance was left aside. The role of antibiotics was simply a neglected aspect in the characteristics of "Italian food", which instead focused on the origin and quality of the end products.

But how come the Italian use of antibiotics is so high compared to both the EU settings "average" and "minimised" use? Below, we take a closer look at the Italian pig meat setting.

5.2 The use of antibiotics in the Italian "big actor" controlled system

Just as in Sweden and other western economies, routine group treatment of pigs with antibiotics for precautionary health and growth was established in the 1950s. In contrast to Sweden and other settings with minimised use of antibiotics in animals, routine group treatment still represents the main part of its use.

Italy has about 32,500 pig farms with about 8.5 million pigs of different sizes and modernity, where the main part of the production volume is managed by large farms located in the north of the country. Behind what might appear as independent farmers hide a system where some hundreds of big integrated companies control the production process, from breeding to slaughter, processing, logistics and marketing of end products (Ismea, 2008). Besides being engaged in pig meat-based food, the big firms are often horizontally diversified: engaged in the production and marketing of chicken, turkey and rabbit-based food. These big players represent 3% of the number of actors engaged in pig meat-based food but own about 85% of the pig livestock.

This implies that the main part of Italian pig meat production is carried out through a contract system between big integrated firms and a myriad of small and medium-sized farmers. This well-known practice in Italy is called "soccida", that is, a specific type of contract common in the agriculture setting, where a big marketing firm uses farmers, slaughterers, and logistic operators to perform certain activities over which it still has a great influence. Or, as described by Battistelli and Campanella (2020, p. 135).

> This is an agricultural contract in which a large producer assigns an operation to a third party but retains complete control over it as if it were still an internal operation.

The main part is that about 90% of the pigs are reared in an "open-cycled production system", where, for efficiency reasons, different farms are specialised at different stages of the breeding process due to the age of the piglets. The sow is most often put in a narrow cage before and after farrowing for 123 days per year on average [29]. The weaning period is made as short as possible. Then, as early as three weeks of age, the piglet can be transported to another farm specialised in the next stage in the subsequent phase of skinning and fattening.

Hence, the "open-cycle" system implies that live animals from different farms are brought together, something that increases the probability of infections, compared to a "closed-system" [30]. Furthermore, mixing piglets from different herds increases stress and aggressive behaviours. To prevent bacterial epidemics caused by the "open-cycle" system, the preventive use of antibiotics as mass prophylaxis is applied, along with tail docking and sanding of teeth. Other aspects driving the use of antibiotics are lack of space and poor health conditions, along with high levels of humidity during hot seasons.

Lastly, although e-prescriptions are implemented, there are still forces that drive the use of antibiotics. The big integrated firms have their own veterinaries employed, to be controlled by state veterinarians. However, the latter can also work as private veterinarians, implying that there is a lack of distinct "firewalls" between the public interest of controlling animal health and the prescription of antibiotics and the commercial interest. Moreover, the high number of micro and small livestock increases the challenge of monitoring the correct use of antibiotics.

The main part of Italian pig meat production is processed into Parma ham and San Daniele ham, and about 35% of these products are exported. The PDO and PGI are important for the companies controlling the production process, and the Consortium of Parma (The Consorzio del Prosciutto di Parma) have also engaged in the establishment of other territory related brands, such as Origin Italia [31].

Although these brands just refer to the food tradition of a specific territory, that is, requirements of pig genotypes, slaughter age, feedstuff and processing, consumers tend to interpret these as also a guarantee for other aspects, such as environmental sustainability and animal welfare (Vitali *et al.*, 2021; Di Pasquale *et al.*, 2014). Hence, the big integrated firms benefit from being associated with animal welfare, which is one of the most important aspects of reducing the use of antibiotics without having to engage in it. Furthermore, most of the small farmers and firms used by the big integrated firms in the soccida system lack the competence and economic resources to invest in animal welfare and related measures to be able to compensate for the overuse of antibiotics. The consumer perceptions of the territory brands applied by the big firms were summarised by Di Pasquale *et al.* (2014, p. 787):

> [. . .]their perception is biased since they expect animal welfare implications in brands or certifications often having a weak or no connection at all with animal welfare on farms, during transport or at slaughter.

The big integrated firms' interest in brand protection seems to hamper their interest in officially highlighting the use of antibiotics. There is a fear of drawing attention to the treatment of animals before the meat is processed into different final products. There is also a lack of studies on the animal welfare situation in the Italian pig setting. Or as Vitali *et al.* (2021, p. 12) summarise:

> In particular, the lack of knowledge on space requirements, injuries, and positive welfare (including the human-animal relationship) are crucial aspects that should be explored in order to define a baseline to set up measures for the improvement of the production system.

Because the use of antibiotics in animals is very absent in the Italian debate, the high level of resistant bacteria, such as LA-MRSA among Italian pigs included, there is a lack of public forces on the big integrated firms to mobilise for and engage in change. However, on the positive side are studies indicating that consumers, if they become aware, are prepared to share the cost of investments in animal health (Di Pasquale *et al.*, 2014, p. 782).

6. Discussion

> Policy makers have to realise that companies never should be treated as standalone units from an economic point of view (Håkansson and Snehota, 2024, p. 122).

In spite of 17 years with the EU ban on antibiotics for animal growth and promotion, the minimised Swedish use is still an exception. Although Italian use has decreased somewhat, it is about 20 times higher than the Swedish. In this section, we will return to the RQ concerning the main forces identified behind the different Italian and Swedish use. We will discuss their characteristics and if and how they have affected direct and indirect resource interfaces based on the analytical framework presented in our research design. That is, how ideas and activated structures, identified through the 4R model (Håkansson and Waluszewski, 2002a, pp. 72–75), have interacted in relation to physical and social resources in the investigated using settings, identified through the notion of three main characteristics related to the use of a resource activated in several user settings (Håkansson and Waluszewski, 2008, pp. 20–22).

6.1 Forces behind the Swedish minimised use

Up to the early 1980s, the forces behind the use was mainly based on what was observed as *wanted* consequences of the focal interface between antibiotics and animals, but also, for a number of other direct and indirect related interfaces.

The observed benefits caused extensive ideas mounting for a rapid integration of routine treatment of groups of animals with antibiotics in the pig meat using setting and in the policy setting. Furthermore, the observed benefits caused a rapid activation of the use of antibiotics, distributed to numbers of direct and indirect related material and social resource interfaces, for example, related to the development and supply of feed, equipment and facilities, to the organisation of manual work, transportation, veterinary services, etc. Although antibiotic resistance was observed, it did not create any significant forces calling for reduced use, but rather for constantly changing the type of antibiotics used in the focal interface and for reserving some types of drugs for human needs. This implied that adaptations and knowledge development related to pig meat production became focused on how to develop related material and social resources to take advantage of the routine treatment of animals with antibiotics rather than how to restrict the use.

The forces that eventually triggered the Swedish engagement in reduced use of antibiotics for food animals became seriously integrated within the focal using setting, in terms of new ideas of how to use antibiotics, initially brought forward by the pig meat producers themselves. These ideas were stemming from what Larsson Heidenblad (2021) labels the "environmental shift". That is the intense public environmental debate characterising the late 1960s, the 1970s and 1980s. The initiating pig meat producers managed to mobilise a number of organisational units and organisational relationships, supporting both a legal ban on the routine use of antibiotics and a radical reduction of the use. The engagement leads up to an integrated adaptation of a number of social and material resource direct and indirect related to the use of antibiotics, to compensate for a radical reduced use.

However, these forces did not trickle down to the retail setting and, for at least three decades, did not give any imprints on related interfaces in this using setting. It was not until the initial idea on environmental consequences of the use of antibiotics had become transformed into a significantly more specified force, focusing directly on antibiotic resistance as a human and animal health challenge and pointing to the role of retailers, that this was integrated and acted on also in the retail setting.

The distribution of consequences of the Swedish ban on routine use of antibiotics; the adaptation of related social and material resources included, were restricted to the pig meat setting, at least during the first three decades of the new using regime. The cost of change expected to be shared in the (protected) agriculture industry–state interface was a miscalculation, especially evident after the EU entrance. The costs for changing interfaces related to the radically reduced use of antibiotics ended up at the pig meat producers' shelf for about three decades, until the increasing attention to antibiotic resistance forced the retail industry to share the responsibility.

It was when the Swedish ban came into force that a significant mobilisation started, in terms of knowledge development and adaptations of both social and material resources to compensate for routine use. The focus was initially directed to affected resource interfaces in the pig meat settings but became, after the EU entrance, more focused on developing scientific evidence for this development path and, furthermore, on the distribution of knowledge to the EU policy setting.

6.2 Forces behind the extensive Italian use

In similarity with the Swedish using setting, the initial idea based on the observed benefits of using antibiotics caused a rapid integration of the forces advocating routine group treatment. The observed benefits were distributed to a number of direct and indirect resource interfaces, allowing industrialisation and specialisation of pig meat production and increased utilisation of space and transportation. Consequently, the knowledge development and adaptations became focused on how to adapt direct and indirect related social and material resources to take advantage of routine use of antibiotics, rather than how to restrict the use.

In contrast to Sweden, neither the late 20th century's environmental debate nor the early 21st century's debate on antibiotic resistance/AMR became embedded into the integrated direct and indirect related using settings. Instead, the call for protecting the origin of Italian food products dominated both the pig meat setting and policy setting. Hence, the forces calling for reduced use, stemming from EU policy and the research community, became poorly integrated in the Italian pig meat setting.

There were, however, at least among the dominating big integrated pig meat producers, an awareness of the challenges related to global and EU policy ideas on the need to reduce the use of antibiotics, and what consequences these would cause if distributed to direct and indirect related resource interfaces. These would imply adaptations and costs of change, which in turn were interpreted as difficult to distribute to retailers and end-consumers. The lack of integration and distribution of forces calling for reduced use of antibiotics did also colour the knowledge development and adaptation of resources. Engagement in a radically reduced use mainly became an issue for small, "organic" producers, independent of the dominating big companies established structure of resource interfaces adapted to take advantage of antibiotics.

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6.3 Coping with cost distribution when reducing the use of antibiotics

Reducing the use of antibiotics within the EU is a significant and ambitious goal, affecting a number of social and material resources both close and distantly connected to the use of these drugs. Although both Sweden and Italy have to cope with the same policy, mounting for a reduced use of antibiotics to combat resistance, the users' way of acting was rather different in these two contexts. These differences point to the importance of considering who can absorb the costs of limiting the use of a particular resource, in this case, antibiotics, in business as well as policy settings. Individual users cannot easily control costs and their distribution within business networks due to the interdependencies formed among heterogeneous actors (Carlsson-Wall *et al.*, 2018). Likewise, taking out a resource – such as antibiotics in the animal-based food industry – and replacing it with novel solutions to keep control of antibiotic resistance/AMR leads to a cost of change that needs to be considered.

The two cases and the attention to how a reduced use of a particular resource are affecting numbers of direct and indirect related resources are rather clear in showing that policy cannot easily deal with cost-related distributing issues (Waluszewski *et al.*, 2017b). Put shortly, the policy focus is directed to a preferred change of a particular resource and not to how this affects established resource structures and how to distribute the short- and long-term cost of change. Furthermore, beyond the fact that policy recognises the benefits of change and innovation at the research and development level (see Perna *et al.*, 2015), the costs for "users" are rather neglected. As made evident through the Italian setting analysis, there is limited attention to the cost of change that a radical reduced use of a specific resource, in this case, antibiotics, would create within the using settings.

6.4 Consequences for policy

What the analysis of the different usage pattern in the Swedish and Italian pig meat setting has revealed is that neither of these was caused by the trickling down of policy advices.

In the Swedish setting, it was forces integrated into the focal using setting that mobilised policy, leading up to a "one-for-all" situation, with a ban on routine use of antibiotics and an extensive engagement in developing resources compensating for a radically reduced use. In the Italian setting, the external forces stemming from EU and global policy were not integrated into the focal using setting, with the lack of a "one-for-all" situation as the most important obstacle. Without the integration of forces calling for a change in related using settings and without the ability to distribute the consequences of change, engagement in adaptations and knowledge development did not occur. Using networks where interfaces for decades have been adapted across business and organisational interfaces to take advantage of the use of a specific resource will defend existing resource combinations, as long as the wanted change does not include substantial possibilities to distribute the costs. Hence, although the need for a change in the use of a certain resource might be seen as obvious from a global health perspective, any such attempt must include an analysis of how the consequences and cost of change can be distributed, that is, shared with others than the direct users.

6.5 Consequences for research

Drawing on the foundational idea that individual users in the network of antibiotic use are not isolated entities, the role of research should be considered as a pivot towards an in-depth exploration of the varied interpretations and adaptations to policy changes by these interconnected users. This research trajectory is poised to unravel the intricate and often subtle impacts that policy shifts exert on the diverse users within this complex network (Perna *et al.*, 2015). By emphasising the interdependencies and the multifaceted interactions inherent in this domain, such a study would not only extend our understanding of the network dynamics but also offer valuable insights for crafting more effective and context-sensitive policies. This approach aligns with the nuanced examination of network relationships and interactions, shedding light on how policies are reacted on across different strata of the network, thereby contributing to a more comprehensive understanding of policy efficacy in the realm of antibiotic usage.

7. Conclusions

The crux of our research addresses the critical issue of the role of policy in reducing the use of a particular resource for health and environmental reasons, when this is embedded in several using settings, in this case, antibiotics for animals. More precisely, our RQ concerned the main forces behind the different antibiotic usage in the Italian, respectively, the Swedish pig meat settings. It implied theoretical and methodological considerations concerning how to outline detailed pictures of the forces related to the different usage patterns, as well as of policy attempts to change these.

Through the 4R model (Håkansson and Waluszewski, 2002b) and the three using aspects (Håkansson and Waluszewski, 2008, pp. 20–22), we were able to outline ideas and activated structures related to the different antibiotic usage patterns in the Swedish, respectively, Italian pig meat settings. Furthermore, we were able to identify very different attempts to create change in time and space, as well as significant differences in how these were integrated into the using settings.

Put shortly, the study points to the importance of an integrating using setting if a reduced use of a resource with significant economic benefits *and* detrimental health and environmental consequences ever will succeed. It requires the integration of new ideas and a systematic, far-reaching engagement in adapting direct and indirect related social and material resources to compensate for the reduced use of a resource, which for decades has been used to create economic benefits. Furthermore, it requires an ability to distribute the cost of change beyond focal users' engagement in developing and adapting resources to compensate for reduced use.

Both these aspects are neglected in contemporary policy. Hence, there is a need for further detailed empirical studies, and for policy considerations, on how to identify, create and support integrating forces of change in different using settings. Furthermore, how to distribute the cost of change to succeed with reducing the use of resources contributing with economic benefits in some settings, and causing severe health, environment and economic consequences in others.

Notes

1 https://ec.europa.eu/commission/presscorner/detail/en/ip_22_663

2 https://ec.europa.eu/commission/presscorner/detail/en/ip_22_663

3 Estimated 1.27 million deaths per year are directly attributable to antibiotic resistance, while 4.95 million deaths are associated with resistant bacteria. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)027240/fulltext

4 ema.europa.eu/en/veterinary-regulatory/overview/veterinary-medicinal-products-regulation

5 The Swedish use is by ESVAC (2021) estimated to be 11.8 mg/PCU and the Italian use is estimated to be 181.8 mg/PCU. The Nordic neighbours Iceland and Norway have the lowest usage levels in Europe (outside the EU but in the European Economic Area, EEA) (ESVAC/EMA 2020).

6 www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

7 www.fao.org/antimicrobial-resistance/en/

8 www.euro.who.int/en/health-topics/health-policy/one-health

9 https://ec.europa.eu/health/system/files/2020-01/amr_2017_action-plan_0.pdf, p. 4.

10 Put shortly, in the *using setting*, the value of a resource is dependent on its contribution to direct and indirect related using system. In the *producing setting*, the value is dependent on the relation to established facility and supply systems. In the *developing setting*, the value of a resource is dependent on how it is related to knowledge development patterns in public research and private R&D (Håkansson & Waluszewski, 2008, pp. 152–155).

11 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:01970L0524-19941208&from=GA

12 www.who.int/antimicrobial-resistance/events/UNGA-meeting-amr-sept2016/en/

13 https://ec.europa.eu/health/system/files/2020-01/amr_2017_action-plan_0.pdf

14 The "Farm to Fork" strategy aims to make food systems "fair, healthy and environmental-friendly".https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en

15 https://ec.europa.eu/health/antimicrobial-resistance/eu-action-antimicrobial-resistance_sv

16 https://ec.europa.eu/commission/presscorner/detail/en/ip_22_663

17 Council Directive 70/524/EEC, 1970.

18 Another new EU member, Finland, had adopted a similar ban as the Swedish and was also given a few years' redemption (Nordeus, 2023).

19 www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-1985295-om-foder_sfs-1985-295 2019-05-17.

20 www.riksdagen.se/sv/dokument-lagar/dokument/proposition/om-djurskyddslag-mm-_GB0393/html Author's translation.

21 https://jordbruksverket.se/download/18.28f4d91b172cdd65219b3acb/1592760271492/201801.pdf

22 www.svt.se/nyheter/utrikes/manga-grisbonder-drabbade-av-mrsa

23 This despite the average suckling period being about one week longer compared to the European average (Gårds and Djurhälsan, 2018).

24 www.gazzettaufficiale.it/eli/id/2017/11/27/17G00180/sg

25 www.who.int/publications/i/item/9789241509763

26 Webinar "Antimicrobial resistance, the One Health approach at the time of the COVID-19 pandemic" organised by Italian Ministry of Health –. streamed live on 18 November 2021. www.salute.gov.it/imgs/C_17_EventiStampa_586_0_fileAllegatoProgramma.pdf

27 https://ec.europa.eu/commission/presscorner/detail/en/ip_22_663

28 These principles were further developed and turned into Reg. (EC) n. 510/2006 of the Council of 20 March 2006, and furthermore, repealed and replaced by the Reg. (EU) no. 1151/2012 of the European Parliament and of the Council of 21 November 2012.

29 The productive life of a sow begins around 10 months of age, when it is introduced to the continuous cycle of insemination, gestation, farrowing and suckling and ends at around three years of age.

30 www.vetinfo.it/j6_statistiche/index.html#/

31 www.prosciuttodiparma.com/parma-ham-consortium/

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