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An assessment of the economic costs to the U.S. dairy market of antimicrobial use restrictions

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ABSTRACT

Antimicrobial resistance is a public threat for humans, generated by the use of antimicrobials in human medicine as well as animal agriculture. Consequently, governments set public policies aim at curbing antimicrobial use (AMU). In dairy production, the occurrence of diseases triggers AMU to limit the costs associated with these afflictions. Therefore, any policies targeting AMU are likely to generate additional costs for farmer, and impact the dairy market. The objective of our research was to assess at the market level the costs associated with potential regulations (a prohibition scenario and tax scenarios) surrounding antimicrobial use in the U.S. dairy sector, comparing to a business as usual scenario. We conducted a two-step analysis, first at the farm and then the market level, to estimate the costs to both farmers and consumers. We found that potential policies restricting AMU would have a minor effect at the market level. In the case of prohibition of AMU, the average milk price would rise from $0.423 to $0.425 per liter. In the short run, the total annual losses would be $152 million. Implementing taxes on AMU would also slightly increase milk price, up to $0.426 in the case of a tax multiplying by five the initial antimicrobial price. Under the prohibition scenario, the quantity of milk produced would decrease by 356 million kilograms, representing 0.4% of the average U.S. milk production over the period 2012–2016. Implementing such policies would lead to a slight increase in costs of production, borne by both consumers and farmers through higher milk prices and lower milk production. As AMU in animal agriculture also fulfills animal welfare and public health objectives, the impacts of restricting AMU should be weighed with these other objectives in policy decisions. Further research is necessary to assess the distributional benefits and costs of AMU policies across farmers, retailers, animal and human health workers, and the public, incorporating multiple dimensions, such as animal welfare and food safety.

1. Introduction

Antimicrobials (AM) are used in dairy production to achieve (i) economic objectives, (ii) animal welfare objectives, ensuring good health of individuals and herds, and (iii) public health objectives, by limiting risk of zoonotic diseases (Lhermie et al., 2017). Except for the use of ionophores, mass medication in feed is less frequent in U.S. dairies compared to other food animal production systems, and generally consists of treating young stock over specific risk periods. Yet, AM are commonly used for mastitis, metritis, and lameness, and in the case of mastitis treatment and prevention, blanket treatment of all cows at dry-off is a frequent practice (USDA NAHMS, 2008). In the U.S., approximately 50% of the 14,000 tons of AM sold in 2016 were used in cattle (FDA, 2017). Although data regarding AM consumption are incomplete in dairy production, several surveys conducted in the U.S. show that antimicrobial use (AMU) is a common practice (Sawant et al., 2005; Zwald et al., 2004). Dairy production generated $34 billion of revenue for U.S. dairy producers in 2016, with 96 billion kg of milk sold, and U.S. milk production is expected to increase to 116 billion kg in 2025 (USDA, 2018a, 2015). In parallel, milk demand is expected to grow at a strong pace, with domestic commercial use of dairy products rising faster than the growth in the U.S. population over the next decade with strong exports (USDA, 2015).

Farmer decisions to treat animals with AM unavoidably lead to the selection of resistant bacteria, which represents a public health threat, as resistant bacteria disseminate in the environment and may affect human beings (Lhermie et al., 2017). Antimicrobial resistance (AMR) therefore, constitutes a negative externality of dairy production. Human health issues have thus led policymakers to implement regulatory instruments such as prohibition and taxes on AMU; recently for

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production purposes in the U.S. (FDA, 2013), as well as for production and therapeutic purposes in several European countries (European Union, 2003; Speksnijder et al., 2015). Yet, the quantitative impact of AMU in animal agriculture on public health is difficult to assess (Singer and Williams-Nguyen, 2014), and any policy regulating AMU should be weighted considering a set of issues, such as food safety, AMR in public health, the farming economy, and animal welfare. To curb AMR, a recent study proposed to implement a tax of 50% on antimicrobial prices, aiming at decreasing by 30% AMU (Van Boeckel et al., 2017). Some research conducted in the beef, poultry and hog sectors investigated the costs of banning subtherapeutic doses of antimicrobials used as growth promoters. In the chicken and pork markets, Sneeringer et al. (2015) showed that the increase in price would be 0.73 and 0.77%, respectively. Graham et al. (2007) found that the net effect of using growth promoters in chickens led to a 0.45% of total costs lost value. In beef cattle, the quantity sold would decrease by 0.63% and 4.21% with a partial or full ban of growth promotion, respectively (Mathews, 2002). A model investigating the ban of growth promotion in pork estimated a 2% the increase in productions costs (Brorsen et al., 2001).

However, the aggregate costs associated with such measures are not readily available for milk production, and have generally been poorly studied, neither prior to nor after their implementation. Acknowledging the complexity of addressing the AMR challenge in animal agriculture, the objective of our research was to assess the economic impacts at the market level of potential regulations surrounding AMU in dairy production.

2. Material and methods

We estimated the impacts of two potential public policies aiming at limiting AMU in milk production: AMU prohibition (Prohibition scenario) and a tax (Tax scenario) on antimicrobials' prices. The approach, which uses a two-step analysis, estimates the costs to both farmers and consumers, at the farm and the market levels.

At the farm level, we use estimates of the impacts from a model we previously published (Lhermie et al., 2018). Briefly, we modelled a representative dairy herd of 1000 cows with an average prevalence for the most frequent diseases in U.S. dairy cows. The effects of regulations on AMU were investigated in the milking herd, and not in growing calves and heifers. The milking herd was modelled as two subsequent lactations, in order to investigate AMU during lactation and one dry period. We calculated the farm net costs of infectious diseases under three scenarios: current AMU practice (Business As Usual scenario (BAU)), AMU prohibition (Prohibition scenario), and an increase in antimicrobial prices (Cost Increase scenario). The BAU scenario corresponded to the current typical practices of AMU in a dairy farm: antimicrobial treatments are supervised by veterinarians, but no specific measure restricting their use is implemented. In the Prohibition scenario, AMU is not allowed in dairy production. Estimates of diseases' prevalences and impacts were extracted from the literature, and were used to calculate the total costs of diseases under each scenario. We computed the cost of each scenario over a two-year period, which takes into account the impact of one drying-off period on the succeeding second year lactation. Then, the cost difference was measured by subtracting the net cost for the BAU scenario from the net cost of each scenario tested. We assumed that farms were homogeneous and that the cost per cow estimated by the model could then be scaled up to the aggregate U.S. milk supply using our representative farm model.

Second, we evaluated the consequences of AMU restrictions at the market-level using estimates of aggregate milk demand and aggregate milk supply. This economic market model was used to determine equilibrium U.S. demand and supply of milk quantity and prices before and after AMU restrictions. This permitted an estimation of producer and consumer economic surplus measures.

In the model, the consumer demand corresponds to the quantity of milk consumers are willing to buy as the milk price varies, all other factors remaining constant. The market demand curve (Fig. 1) describes this relationship between the price of the commodity and the aggregate quantity of milk purchased by all consumers. The price elasticity of demand (E_D) expresses the percentage change in quantity demanded in response to a given percentage change in price. The market supply curve (Fig. 1) corresponds to the aggregated quantity of milk produced. Even if in practice, each producer has different marginal production costs, the market supply curve combines the responses of all dairy farms to a price change.

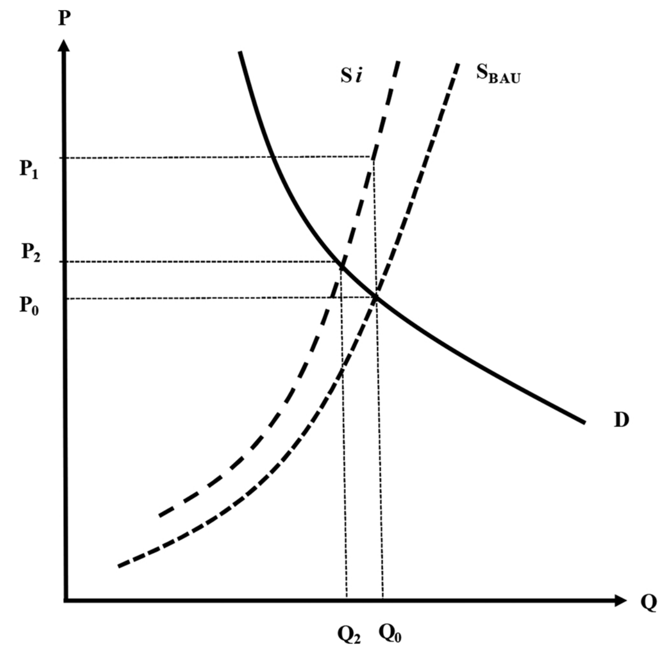

Fig. 1. Graphical representation of the milk market before and after the implementation of a restriction on antimicrobial use. The original supply curve (S_{BAU}) intersects with the demand curve (D) at the equilibrium quantity Q_0 and price P_0. A restriction of antimicrobial use lead to a shift to the left of the supply curve (S_i), and a new equilibrium is reached at quantity Q_2 and price P_2.

We assumed aggregate milk demand and supply curves by using constant elasticity functions, of the form:

$$Q_{0D} = A\,P_0^{E_D} \tag{1a}$$

$$Q_{0S} = B\,P_0^{E_S} \tag{1b}$$

Where Q_D is the aggregate demand for milk at price P, and at that price the aggregate supply of milk is Q_S. We assumed an equilibrium price P_0 occurred and the market cleared at Q_0. That implies that $Q_{0\,D} = Q_{0\,S}$, and with that substitution, we can solve for the market clearing price for milk as:

$$A\,P_0^{E_D} = B\,P_0^{E_S} \tag{2a}$$

The market clearing quantity of milk can then be determined by inserting the solution for this price into either the demand (1a) or supply (1b) function.

To estimate the aggregate demand function, we used the average aggregate demand of milk Q_0, that was produced in the U.S. over the period 2012–2016 (USDA, 2018a), the average milk price P_0 received by farmers over those 5 years (Wisconsin University, 2018; USDA, 2017), and a published elasticity of demand of -0.65 (Andreyeva et al., 2010). We assumed that elasticity was effective at the quantity and price of milk over the 5 years. We model demand as consisting of demand both domestically and internationally. It is only recently that the U.S. has exported any significant quantity of milk products, moving from about 3 percent of production prior to the year 2000 to 15 percent in 2014 (Blayney et al., 2016). Because the international market is