Animal health and price transmission along livestock supply chains

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Summary
Animal health diseases can severely affect the food supply chain by causing variations in prices and market demand. Price transmission analysis reveals in what ways price variations are transmitted along the supply chain, and how supply chains of substitute products and different regional markets are also affected. In perfect markets, a price variation would be completely and instantaneously transmitted across the different levels of the supply chain: producers, the processing industry, retailers and consumers. However, empirical studies show that food markets are often imperfect, with anomalies or asymmetries in price transmission and distortions in the distribution of market benefits. This means, for instance, that a price increase at the consumer level may not be transmitted from retailers to processors and producers; yet, on the other hand, price falls may rapidly affect the upstream supply chain. Market concentration and the consequent exertion of market power in key segments of the supply chain can explain price transmission asymmetries and their distributional effects, but other factors may also be involved, such as transaction costs, scale economies, and imperfect information.

During the bovine spongiform encephalopathy (BSE) crisis, asymmetric price transmission in the beef supply chain and related meat markets determined distributional effects among sectors. After the spread of the BSE food scare, the fall in demand marginally affected the price paid to retailers, but producers and wholesalers suffered much more, in both price reductions and the time needed to recover to pre-crisis demand.

Price transmission analysis investigates how animal health crises create different economic burdens for various types of stakeholder, and provides useful socio-economic insights when used with other tools.

Keywords

Introduction
Animal health has far-reaching effects across society. Animal disease outbreaks severely affect not only production potential but also people and the whole socio-economic system. Terms such as ‘food alert’, ‘food recall’ and even ‘food crisis’ (1) are used to describe such situations, according to the seriousness and context of the events. In this paper, the authors treat a specific aspect related to animal health and food crises: the way in which the prices of foods derived from livestock are transmitted across economic sectors when an animal health crisis occurs.

Price transmission is a very specific aspect of economic analysis, since it involves both practical and conceptual issues, which are essential to the functioning of the socio-economic system. During recent decades, economists have become conscious of the importance of price transmission studies to assess market efficiency and detect anomalies, focusing in particular on agro-food markets. Applying price transmission analysis to the specific case of animal health
crises gained momentum during recent animal health emergencies, such as bovine spongiform encephalopathy (BSE) and avian influenza outbreaks.

The first section of the paper is a general exploration of the functional links between the main concepts described in this paper, namely, the food supply chain, animal health and price transmission. The authors then provide a brief insight into the background of price transmission and consider the main definitions of the term and the related economic implications. They then review some significant price crises related to animal health issues in the literature and finish with concluding remarks.

Linking animal health, supply chain and price transmission

In 1996, links between BSE, detected a few years earlier in the United Kingdom (UK), and a variant of Creutzfeldt-Jakob disease (CJD) causing human death were discovered and announced. National and European health authorities took measures to limit the spread of the disease among animals and humans, such as export bans, the culling of infected animals or those exposed to the risk of infection, and specific hygiene measures in abattoirs to remove potentially infected material (2). Meanwhile, a food scare began. Many consumers reduced their beef consumption after media announcements on BSE and CJD, leading to a change in overall beef demand and a move towards alternative meats, mainly pork and poultry. BSE policy measures and/or the adaptation of consumption occurred all over the world, though the strength of these measures and their duration varied widely. There are published examples from North America (3), Korea (4), Spain (5), and Japan (6).

Epidemiological and socio-economic models that combine biological transmission patterns with the economic flow of goods and services help us to understand the effects of animal disease outbreaks. When food is involved, food scares amplify and add complexity to the impact of animal disease. The concepts of ‘value chain’ (7) and ‘food supply chain’ (8) are useful in understanding such effects, as they allow us to trace the technical and economic interactions through which animal products impact upon society in times of animal health crises. In particular, the ‘food supply chain’ approach more clearly illustrates the authors’ argument. Figure 1 shows a simplified example of the beef supply chain.

The flow of goods along the food supply chain occurs through a series of market exchanges. At each step along the chain, the outputs of one segment become the inputs of the next segment. Inputs are technically transformed (processed) and value is added, until final consumption. Technical and economic aspects are governed by private and public rules and their enforcement (i.e. the strategies of private firms and, in the case of government, public policies), which define the supply chain’s governance. During an animal health crisis, private firms adapt their strategies to the new situation, while public authorities adopt emergency and structural measures to minimise damage and to fill gaps in the private sector’s response. Such public-sector measures involve health and food-safety policies, economic policy and trade policy. Subsequent changes in governance influence the dynamics of the crisis and have an impact on market equilibria, leading to changes in product demand, production volume and prices.

Price variations occur within the whole process: vertically, along the supply chain of the directly affected products; horizontally, via inter-regional and international trade; and indirectly, through supply chains of substitute products. In this context, according to economic theory, a perfectly functioning market should rebalance the whole agro-food system by transmitting, in the form of price variations, information on changes in consumer preference and the availability of supplies from one operator to another. Analysing price transmission can test the effectiveness of the market in accomplishing its function and disclose potential failures that lead to the sub-optimal allocation of resources, creation of undue rent, and altered distribution of market benefits among the different industries and stakeholders involved.
The conceptual framework behind price transmission analysis

Price transmission is a variation in the market price of one good, caused by a variation in the market price of another good. Studies in this field aim to understand how price variations in a market are transmitted to other related markets and over what time period. The theoretical and empirical relevance of such studies is connected with market efficiency, as defined by hypotheses of the Walrasian General Economic Equilibrium: a theoretical system of perfect markets where, among other things, price variations in the market of one product are assumed to be perfectly and immediately transmitted to the markets of all the other products (9).

To introduce the main concepts of price transmission, it may be useful to examine some notions derived from industrial organisation theory and subsequent developments. In particular, the structure–conduct–performance model is relevant, as it postulates that the structure of an industry or market, described by the degree of industrial concentration, determines the strategies of private firms in terms of competition and collusion, and thus the performance of both the market and the firm, i.e. market efficiency and the firm's profit, respectively (10). In very concentrated industries, dominated by monopolies or collusive oligopolies (i.e. markets characterised by the presence of few suppliers, who can easily agree common strategies instead of competing), firms may exploit their market power against customers by avoiding lowering the selling prices of their products when the price of purchased inputs is reduced. Monopolistic firms may also gain extra profit by excluding their suppliers from any benefit, when the expansion of final demand allows their products’ prices to increase. In this framework, the analysis of imperfect, or asymmetric, price transmission may be assumed to reveal the exertion of market power.

A relevant critique of the classical structure–conduct–performance model is that the structure of an industry is not determined by external forces, but depends on the internal strategies of firms, which act to gain more market power by modifying the structure of the industry (11). However, empirical and theoretical developments in price transmission studies suggest that market power is just one of the possible causes of asymmetric price transmission, which may also include: transaction costs, menu costs, stock management criteria, the technical production cycle, economies of scale, asymmetric information and the spatial organisation of the supply chain (12, 13, 14, 15).

Price transmission patterns

When price transmission takes place along the supply chain of one commodity, it is called ‘vertical’ price transmission (13). For example, an increase in the price of raw milk at the farm gate causes an equivalent increase in the production costs of butter in the dairy industry, which is incorporated in the price of butter from the factory and then goes into the retail price. Vertical price transmission is related to the processing and transformation of commodities along the food supply chain, in which the output of one segment is the input of the subsequent segment, up until final consumption.

‘Horizontal’ or ‘geographical’ or ‘spatial’ price transmission occurs when a variation in the price of one commodity in one marketplace is triggered by a price variation of the same commodity in another marketplace (16). For example, a variation in the wholesale price of butter in Germany causes a variation in the wholesale price of butter in the Netherlands. This is related to the sellers’ ability to trade their goods in the most profitable marketplace, taking into account transportation, logistic and transaction costs, and other related fees, e.g. trade tariffs, administrative costs, compliance with local regulations, etc.

‘Cross-commodity’ price transmission takes place between substitute goods (17): for example, an increase (or reduction) in the price of beef may lead consumers to reduce (or increase) their beef consumption and demand more (or less) lamb. This may then cause an increase (or reduction) in the price of lamb.

As mentioned above, in a perfect market characterised by the theoretical conditions of perfect competition, it is assumed that a variation in the price of a given commodity should ‘perfectly’ transmit itself to the price of all related commodities. This means, for example, that, in a perfect market of dairy products, an increase in the price of raw milk should result (all other things being equal) in an instantaneous increase in the prices of all dairy products. This increase would fully correspond to the additional expenditure on raw milk (and/or related downstream products) in the respective production processes.

According to such hypotheses, market inefficiencies are supposed to cause imperfect or ‘asymmetric’ price transmission. For instance, if a reduction in the price of raw milk does not affect the retail prices of dairy products, this may be caused by the monopolistic behaviour of processors or retailers, who take over the entire social gain of the price decrease by excluding consumers from any benefit. A price transmission analysis may then indicate the presence of market inefficiencies, causing a different distribution of benefits among stakeholders from the one that would occur
if the market were functioning correctly. Price transmission analysis may also allow quantification of the welfare transfer (12).

Research in this field focuses on two aspects: the magnitude and speed of price transmission (see Fig. 2). The former refers to the quantitative extent of the induced price adjustment ($P_2$ in Fig. 2), with respect to the first price variation ($P_1$ in Fig. 2). The latter refers to the time lag before the adjustments take place. Hence, analysts must first distinguish asymmetries in the ‘magnitude’ of price transmission from those in the ‘speed’, as well as from those in the ‘magnitude and speed’. As observed in Figure 2, asymmetries in magnitude generate a permanent transfer of benefits, while the transfer is only temporary for asymmetries in speed. Asymmetries in magnitude and speed imply a mixture of temporary and permanent transfers (12).

A second criterion for distinguishing asymmetries involves the dynamics of induced price adjustments. These may differ according to whether the adjustment is a price increase or a price decrease. A ‘positive’ asymmetry indicates that the induced adjustment is faster and/or more complete when prices increase, than when they decrease. A ‘negative’ asymmetry indicates the opposite (12, 18). For example, positive asymmetry takes place when, along the supply chain of a given farm product, a price increase due to poor harvest is immediately and fully transmitted from farmers to consumers, however, a decrease in the farm-gate price due to oversupply is not passed on to consumers. A European Commission working document demonstrates positive asymmetries in the European dairy market in the 2000s, especially after a dramatic price increase during the summer of 2007 (14).

A negative asymmetry can occur when fears of an animal disease outbreak cause a fall in consumer demand for a given animal product, leading to a fall in the consumer price, which is immediately and fully transmitted to the farmers. However, once the outbreak is resolved, the recovery in demand and price at the consumer level is slowly and only partially transmitted to farmers. As shown below, studies on price transmission asymmetries in the beef market related to BSE show that these dynamics raise issues of rent distribution among retailers, on the one hand, and wholesalers and farmers, on the other (5).

One last criterion for classification is related to the type of price transmission in which such asymmetries occur. In fact, as stated previously, we may distinguish between ‘vertical’ asymmetric price transmission, which occurs along the product supply chain; ‘horizontal’ asymmetry in inter-regional price gaps; and ‘cross-commodity’ asymmetric price transmission among substitute products (12, 16, 17, 19).

As shown above, most of the literature cites uncompetitive markets as a main cause of price transmission (12, 14). The food supply chain has a great diversity of market structures. For each product, the various segments of the supply chain have different levels of market concentration and varying degrees of integration with connected segments. Furthermore, the types of business involved show great variation from small family enterprises to large transnational corporations. In addition, the supply chain structure for the same type of product may change significantly between countries. Input-output connections along the chain dictate that firms operating in more concentrated segments attempt to exert market power against their suppliers or customers who operate in the directly linked but less-concentrated segments. In general, food supply chains are particularly fragmented in the most upstream segments, such as farm production, which is mainly dominated by family businesses, and downstream segments, i.e. the final consumers. For this reason, it is often assumed that farmers and consumers are the main victims of asymmetric price transmission, caused by wholesalers, processors and, to a greater extent, big retailers exerting their market power in the intermediate segments. However, in the empirical studies available, evidence of asymmetric transmission due to the exertion of market power is not always so obvious. In most cases, the presence of asymmetries is detected but causes related to unbalanced market power are not
Price transmission and animal health

Various studies provide evidence of different price transmission patterns, particularly vertical price transmission, in the agro-food sector, but only a few focus on price transmission in relation to animal health crises. Among these, BSE has been well studied, followed in recent years by avian influenza (25, 26). The authors thus examined BSE studies to explore the evidence on the conceptual background of price transmission and animal health.

The relationship between the BSE crisis and vertical price transmission was first investigated in 2001 in the UK (27). This study found that news of the relationship between BSE and variant Creutzfeldt-Jakob disease led to an immediate 40% fall in beef demand, followed by the complete loss of beef exports. Beef prices subsequently fell, showing asymmetries along the supply chain, since ‘beef prices at the retail level declined significantly less than at the producer level, resulting in a substantial increase in the retail–producer price margin’. The concentration of the retail sector (67% of the retail market was controlled by five companies) could explain this effect.

In the United States, Livanis and Moss (3) observed that, during the 1990–2004 period, the real price of beef declined by about 5% in the retail sector, while wholesale and farm prices declined by 38% and 37%, respectively. During the same period, the spread in prices increased but the difference between the retail and the wholesale price increased five times more than the price difference between the wholesale and the producer level. Again, in this case, retailers’ market power could explain this result.

In Spain, the BSE crisis resulted in a modification of the price formation mechanism between producers and consumers. The first effect of the BSE announcement was a 19% decrease of beef consumption in 2001, which was recovered in later years. Asymmetries appeared in the way in which BSE affected different stages of the supply chain, with retail prices being less sensitive to demand shock but producer prices running the entire gamut of all the adjustments caused by consumer shock (5).

On studying several animal health crises in Korea, Park et al. (4) confirmed the existence of asymmetric price transmission between the retail and upstream sectors. One emerging aspect of this research was a comparison between three different animal health crises: BSE in 2003, foot and mouth disease (FMD) in 2000, and avian influenza in 2003. Demand shocks occurred in all three cases. Retail prices recovered from the adverse effects of the crises after 13 months in the case of avian influenza and BSE, and 16 months in the case of FMD. The wholesale and farm prices of pork (in the case of the 2000 FMD outbreak) and the farm price of beef (in the case of the 2003 BSE outbreak) took about three years to recover. During the 2003 BSE and avian influenza outbreaks, substitution effects benefited the pork market but just for a short period. In general, retail prices recovered much faster than wholesale and farm prices. In fact, despite an initial drop, the retail price widened its margins against wholesale and farm prices, whereas the wholesale-to-farm price margin remained relatively steady. In this case, market asymmetries favoured the retail sector.

As for consumers, the studies cited above demonstrated substitution effects among different types of meat (e.g. beef versus pork and poultry during the BSE outbreak; beef and poultry versus pork during the FMD outbreak), but no further analysis took place to examine price transmission in the supply chains of substitute products. Demand shock deserves particular attention in this framework. Several authors (3, 27, 28) have argued that price transmission also depends on the scale of the crisis, and empirically tested this assumption by constructing a food-scare information index (FSII), based on news counts about the animal health crisis in question. According to Livanis and Moss (3), a one-point variation in the FSII has a more rapid effect at the retail level than at the producer and wholesale levels, where prices take more time to recover after a demand shock. For more information about the FSII, see the studies of Hassounah et al. (5, 25).

Unfortunately, the available literature provides few insights into animal health issues and horizontal price transmission, although there is information on globally traded crop commodities. Horizontal transmission analysis is often used to evaluate international integration of commodity markets. Studies in this area gained momentum during the establishment of the World Trade Organization (WTO) and the implementation of global trade agreements. In the European Union (EU), studies were conducted on the efficiency of the Common Agricultural Market and its integration into the global market; see, for example, the study of Liu on the Finnish meat sector (28). Some commodities are of particular interest in this context because of the effect of the Common Agricultural Policy on domestic and world trade – see, for example, Listorti and Esposti (16) and Aragrande et al. (29) – and the way that prices are transmitted across EU borders.

Concluding remarks

Figure 3 provides a more complete picture of the relationship between animal health crises and price transmission within the food supply chain. Basically, it displays the flow of goods and services from upstream sectors in the chain through to consumers, with intermediate technical steps related to production, processing and retailing.

In the case of BSE, the disease originates upstream (on the farm) and is detected in nearby sectors (slaughterhouses, wholesalers). The presence of BSE has led to rigorous implementation of animal and public health measures in Organisation for Economic Co-operation and Development (OECD) countries and their trading partners. These countries took public action, disseminating social information that immediately raised concerns among consumers, which were translated into sudden demand shocks. Probably the most relevant effects of BSE start at the consumer end of the supply chain and escalate across the chain as feedback.
An unequal distribution of market power along the supply chain enables the relative rigidity of consumer prices, i.e. consumers do not gain. At the same time, sectors with more market power (e.g. retailers) may increase their margins, imposing lower prices on the upstream sectors (namely farmers, who might, however, receive some compensation for primary losses due to culling), with an intensity in relation to the scale of the crisis. Price transmission analysis may reveal the distributional effects of animal health crises, i.e. how the burden is distributed among stakeholders.

Demand shock may have other effects. If customers perceive that ‘safe’, substitute products exist, demand for these products will increase, along with the prices, and there will be a replay of the price transmission process across the supply chains of these products. This process may be asymmetric and have unbalanced distributional effects, depending on the structure of their supply chains. Substitute products may also be obtained from abroad, starting a growing flow of imports. In the countries where the new imports originate, local supply chains may transmit asymmetries in price variation and correlated distributional effects to foreign stakeholders.

All of these impacts may run along different time periods, according to the epidemiology of the disease, the effectiveness of the health measures undertaken and the consumer response to the crisis. Recovery of the former animal health status may occur but production and supply chains are likely to have been altered and prices and the spread of benefits changed. Changing economic conditions during the crisis (e.g. farms ceasing production because of lower prices, ongoing industrial restructuration, the adoption of costly controls and private safety procedures, changing consumer preferences) may induce permanent structural changes in the supply chains of the affected products, due to new situations.

In conclusion, price transmission analysis, used in political economy studies to test and explain the degree of market efficiency, may be used in applied studies on animal health disease to assess and explain distributional effects along the supply chain. The food supply chain concept and price transmission analysis enable us to examine localised effects among sectors and across space and time. This, in turn, provides complementary information and more contextualised explanations, in comparison to other micro- and macro-economic approaches.

La santé animale et la transmission des prix dans la filière des productions animales

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Résumé
Les maladies animales peuvent avoir de graves répercussions sur la filière agroalimentaire en occasionnant une instabilité des prix et de la demande. L’analyse de la transmission des prix met en lumière la manière dont les variations de prix se transmettent tout au long de la chaîne d’approvisionnement et leurs conséquences sur les productions de substitution et sur les différents marchés régionaux. Dans un marché parfait, toute variation de prix se répercute de manière intégrale et instantanée à chaque niveau de la chaîne d’approvisionnement :
producteurs, transformateurs, détaillants et consommateurs. Des études empiriques ont toutefois montré que les marchés de l’agroalimentaire sont souvent imparfaits, avec des anomalies ou des asymétries dans la transmission des prix ainsi que des distorsions dans la répartition des bénéfices commerciaux. Ainsi, par exemple, une hausse du prix payé par le consommateur ne se transmet pas nécessairement du détaillant aux transformateurs et aux producteurs, tandis qu’une baisse des prix affecte très rapidement la chaîne en amont. Si les asymétries de la transmission des prix et leur impact distributif peuvent s’expliquer par la concentration des marchés et par la puissance commerciale exercée par des segments clés de la chaîne d’approvisionnement, d’autres facteurs entrent également en jeu, tels les coûts de transaction, les économies d’échelle et les failles de l’information.

Lors de la crise due à l’encéphalopathie spongiforme bovine (ESB), l’asymétrie de la transmission des prix au sein de la chaîne de viande a eu pour conséquence un impact distributif parmi les secteurs concernés. Suite à la panique causée par l’ESB, la chute de la demande a eu des répercussions marginales sur le prix payé aux détaillants, tandis que les producteurs et les grossistes ont été beaucoup plus affectés, non seulement par la chute des prix mais aussi par le temps qu’il leur a fallu attendre avant que la demande retrouve son niveau d’avant la crise.

L’analyse de la transmission des prix permet de comprendre la diversité des répercussions économiques d’une crise de santé animale et de fournir une éclairage socio-économique précieux lorsqu’elle est utilisée parallèlement à d’autres outils.

Mots-clés
Analyse de la transmission des prix – Concentrations – Crise de santé animale – Filière agroalimentaire – Transmission des prix.

Sanidad animal y transmisión de precios en las cadenas de suministro de productos ganaderos

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Resumen
Las enfermedades de los animales pueden resultar muy perjudiciales para la cadena de suministro alimentario por las oscilaciones que provocan en los precios y la demanda del mercado. El análisis de la transmisión de precios revela de qué manera las variaciones de precios se transmiten a lo largo de la cadena de suministro y cómo afectan también a las cadenas de suministro de productos sustitutorios y a mercados regionales diferentes. En un mercado perfecto, la variación de un precio se transmitiría de forma completa e instantánea a los distintos eslabones de la cadena de suministro: productores, industria transformadora, minoristas y consumidores. Sin embargo, los estudios empíricos demuestran que los mercados agroalimentarios suelen ser imperfectos y presentar anomalías o asimetrías en la transmisión de los precios, así como distorsiones en la distribución de los beneficios comerciales. Ello significa, por ejemplo, que un aumento de precio a nivel del consumidor puede no transmitirse de los minoristas a los transformadores y productores. Por otro lado, en cambio,
las caídas de precios pueden afectar rápidamente a los primeros eslabones de la cadena de suministro. La concentración del mercado y el consiguiente ejercicio del poder de mercado en segmentos clave de la cadena de suministro pueden explicar las asimetrías de la transmisión de precios y sus efectos en la distribución, aunque también es posible que intervengan otros factores, como los costos de transacción, las economías de escala o las imperfecciones de la información.

Durante la crisis causada por la encefalopatía espongiforme bovina (EEB), la transmisión asimétrica de los precios en la cadena de suministro de carne vacuna y en los mercados cárnicos conexos trajo consigo una serie de efectos distributivos entre los sectores. Cuando cundió la alarma causada por la EEB, la caída de la demanda afectó solo de manera marginal al precio pagado a los minoristas, pero en cambio productores y mayoristas sufrieron mucho más, tanto por la caída de precios como por el tiempo necesario para que la demanda recuperara los niveles previos a la crisis.

El análisis de la transmisión de precios estudia cómo las crisis zoosanitarias imponen una carga económica variable a las distintas partes interesadas y proporciona información socioeconómica de utilidad cuando se emplea en combinación con otras herramientas.

**Palabras clave**

Análisis de la transmisión de precios – Cadena de suministro agroalimentario – Concentración – Crisis zoosanitaria – Transmisión de precios.

**References**


