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# Financing Agricultural Value Chain RD&E: An Alternative Approach with Examples from the Red Meat Industry[1]

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## Abstract

Agricultural RD&E managers have responded to the increased focus on value chains in food and agricultural product markets and most Australian agricultural RD&E corporations now have value chain programs embedded in their portfolios of funded projects. As community concerns have intensified within the social, environmental and public health spheres, the agricultural RD&E corporations also have started to invest some resources in areas of research which have externality implications. However, the assessment processes they use typically have not kept up with these changes, and some are questioning the basis of the current approaches when whole-of-chain and externality issues are important considerations. In this paper, the idea that agricultural value chain RD&E results in 'chain goods' is linked with Swann's idea of a 'club goods solution' to research funding, to argue that a 'chain goods solution' can be a viable means of funding research activity that relates to agricultural value chains. Thus, members of a value chain need not rely solely on government to fund value chain RD&E. A set of criteria is suggested to determine who should fund RD&E activities in Australian agricultural value chains depending on the relative balance between expected private, chain and social benefits.

***Key words***: Chain goods; collaboration; meat; RD&E; value chain

## Introduction

Economists have long argued that food and agricultural product research, development and extension (agricultural RD&E) is a public good. Large numbers of small farmers do not have the resources themselves to invest in, and do not have access to the legal mechanisms to capture the benefits from, successful agricultural RD&E[2]. As well, there are many benefits from successful agricultural RD&E that spill over into the wider community. Recipients of these benefits pay none of the cost of this RD&E.

[1] This is a substantially revised version of a chapter in Griffith et al. (2014). We thank Meat and Livestock Australia for funding that project. We also thank two referees for comments which have improved the paper.
[2] In evaluating the worth of agricultural R&D, the standard approach is to identify those projects for which the present value of benefits exceeds the present value of costs.

Thus, public funding aims to supply agricultural RD&E outputs by filling the RD&E funding gap. Therefore, there has been a justifiable role for national and regional governments in agricultural RD&E by funding projects where returns are insufficient for a private party to invest in a research project. Mallawaarachchi et al. (2009, p. 2) expressed the argument as follows: 'a 'positive spillover' effect – the potential for many parties to obtain a benefit from research, beyond those directly involved in the research – and the [in our view, consequent] public good[3] characteristics of knowledge generated through agricultural RD&E … justify government intervention in agricultural research and development activities'. A failure to intervene could mean that socially beneficial agricultural RD&E projects may not be undertaken.

In Australia there is a system of RD&E corporations for different agricultural industries that are part funded by industry levy payers (typically farmers but often also other value chain members), and part funded by the Australian government, on the basis of the above principles (Productivity Commission, 2011). For example, the current arrangement for red meat RD&E funding is that the Federal Government pays one-half and an industry levy contributes the other half. However, several emerging issues are signalling the need for a change in these arrangements.

First, over the past two decades, there has been an increasing focus on value chains as the best way to think about food and agricultural product markets. Much of this interest has been generated by large food manufacturing and retailing firms in developed countries seeking more than just efficient supply chains (see for example, the material in Burch and Lawrence, 2007; OECD, 2007; Chopra and Meindl, 2013; Deloitte Touche Tohmatsu Ltd., 2013). Another strand of the interest has been in the application of value chain principles to agricultural product markets in the developing world (see for example recent publications by the United Nations (FAO, 2014, 2015), the World Bank (FIAS, 2007; Webber and Labaste, 2007), and various international development agencies (Kaplinsky and Morris, 2001; Department for International Development, 2008; Springer-Heinze, 2007)). Overlaying these developments has been an expanding academic literature (Soosay et al., 2012; Griffith et al., 2015; Bokelmann et al., 2015; Baker et al., 2016).

With this increasing focus on value chains and the role of the consumer in agricultural product markets, and since most of Australia's agricultural output, either for domestic markets or for export, enters value chains, researchers have targetted improving the value chain as opposed to a narrow focus on improving agricultural production. Agricultural RD&E managers have followed suit and most Australian agricultural RD&E corporations now have value chain programs embedded in the portfolio of funded projects. For example, the focus in Australian red meat industries has shifted recently to agricultural RD&E within the value chain. A series of projects were implemented to develop 'an Agri-food Innovation Hub for the red meat industry … to deliver a transformational outcome based on customer and market-focused innovation and building capability throughout the value chain' (MLA, 2015). The Hub was recently modified and repositioned as 'Innovation Insights' (MLA, 2015) to stress the primacy accorded to innovation in the framework for the study of red meat value chains. A recent study (Heath et al., 2018) has attempted to re-emphasise the benefits to red meat producers from being involved in value chains.

The emphasis on collaboration in RD&E throughout the value chain is evident across many other Australian rural industries. A good example is the Australian grains industry, particularly in light of the

[3] A public good is a good for which 'the marginal cost of provision to an additional consumer is zero and people cannot be excluded from consuming it' (Pindyck and Rubinfeld, 2001, p. 644). Thus public goods are non-rival and non-price-excludable.

industry prioritizing increased grain quality to add value in the chain. According to GRDC (2016, pp. 5-6):

> Collaboration is at the heart of the GRDC's approach to adding value to the Australian grains industry. The majority of the GRDC's investment in RD&E is with partners that co-fund the work and conduct many of the activities. Examples include government agencies; research organisations, including cooperative research centres, universities and other rural RD&E corporations; commercial plant breeders and seed companies; agricultural companies and advisers; and grain marketers, exporters and end users. … The GRDC also works with commercial partners to deliver the outputs of GRDC-funded research to growers in the form of new technologies and services. Historically, GRDC investment partners have been public institutions such as state governments, CSIRO and universities. Increasingly, however, investment partners include a mixture of large, medium and small enterprises from the public and private sectors.

The pivot by GRDC towards RD&E encompassing the whole value chain began early this century, as reflected in the final report of Project BDA1 (GRDC, 2002). The main aim of the project was 'to understand how value can be created, and how this additional value can be captured by Australian wheat growers'.

Similar sentiments have been expressed by Dairy Australia in respect of the dairy industry: 'It is vital that the work of Dairy Australia aligns with industry and community needs. Collaborating with our partners and stakeholders delivers more effective and valuable commercial and social outcomes than could be achieved if the same work were carried out by individuals.' (Dairy Australia, 2016, p. 17). In 2014, the Dairy Innovation Hub was established to increase commercial research contracts undertaken in collaboration with industry participants (Dairy Australia, 2016, p. 39).

Similarly, a priority of Horticulture Innovation Australia Limited (HIAL) is to grow the horticulture value chain through the adoption of innovations emanating from RD&E projects (HIAL, 2016, p. 23). HIAL 'works in collaboration with industries … to encourage people to buy, eat, grow and enjoy more horticultural products, helping growers maximise their returns [and] helps industries to develop export opportunities and invests in key RD&E to gain or maintain market access to build overseas demand' (HIAL, 2016, p. 27).

Along with this increasing interest in value chains, as community concerns have intensified within the social, environmental and public health spheres, the agricultural RD&E corporations have started to invest some resources in areas of research which have externality implications[4]. There is therefore an increasing likelihood of the nature and distribution of external benefits being part of the agricultural RD&E project selection and funding process.

What of the assessment approaches the agricultural RD&E corporations use to choose which projects and programs to fund? There is no doubt that over the past five decades, impressive theoretical and methodological advances have been achieved in the economic evaluation of research investments and the distribution of their benefits and costs throughout the value chain. This work began with Griliches (1958) and Peterson (1967) in the United States and with Duncan and Tisdell (1971) in Australia. During the 1980s and subsequently, these advances have been formalised and popularised by Alston and colleagues, much of which has been published in the Australian literature (see for example, Mullen et al., 1989; Alston, 1991; Alston and Mullen, 1992; Alston et al., 1997; Alston et al., 2004).

[4] A referee has noted the irony that the RD&E corporation established specifically to deal with natural resource market failures (Land and Water Australia) was abolished in 2009.

However, it is clear that funding bodies have not taken advantage of these advances and confine themselves to simplistic estimates of the distributions of expected benefits and costs through the value chain. Three reasons can be proffered for the lack of take-up. First, determining appropriate distributions of benefits and costs using the analytical methods underlying these advances is both time-consuming and costly. Second, data requirements are formidable to meet in undertaking such analyses. Third, these analytical methods assume that the appropriate burden of the levy will spread throughout the chain according to the relative price elasticities of demand and supply at each stage. This may be a satisfactory solution in situations where competition largely prevails throughout the chain,[5] but such a situation may not exist in agricultural value chains in Australia on two counts.

First, market imperfections exist in many markets – particularly, market concentration where few participants operate at some stages in the chain – that open up the possibility for large firms to exert market power by using pass-through pricing methods that favour them[6]. The extent to which this occurs varies according to the number of firms at each stage in the chain, demand and supply curvature, vertical supply relationships, strategic interactions between firms, relationships between industry structure and pricing, and the extent of differentiation among products passing through the chain (RBB Economics, 2014). Such a situation has been studied in the formal literature (for example, Alston et al., 1997), but as far as we can tell has not been integrated into agricultural RD&E corporation decision processes.

Second, the formal competitive equilibrium theory which underpins these types of models is based on optimisation behaviour by individual entities – profit maximisation by individual firms, and utility maximisation by individual consumers. The whole idea of well-functioning value chains is that the individual businesses that make up the chain act jointly to maximise whole-of-chain surplus rather than individual firm profits. This is especially the case when external costs and benefits are likely to result from funding decisions. Assessment processes based on competitive equilibrium assumptions do not account for externalities.

Thus, the typical funding models used by the agricultural RD&E corporations have not kept up with changes in the types of projects being assessed and the range of expected outcomes. Some are questioning the basis of the current arrangements. For example, this issue was a major focus of a report by the Productivity Commission on funding agricultural RD&E in Australia. The Commission (Productivity Commission, 2011, p. 273) made a series of recommendations, finding that '… the case for public funding contribution does not centre on the public-private balance in research benefits as such. What is important is whether or not there are sufficient potential returns for a private party to invest in a project. If there are, then the case for public funding is weak, even if there are subsequently wider benefits for the rest of the industry as the innovation concerned takes hold.'

[5] Subject to the standard welfare (deadweight) loss from imposing a levy (Pindyck and Rubinfeld, 2001, p. 316).

[6] For example, Griffith (2000) and O'Donnell et al. (2007) studied the exertion of market power in food value chains in Australia. O'Donnell et al. found 'evidence of flour and cereal food product manufacturers exerting market power when purchasing wheat, barley, oats and triticale; beer and malt manufacturers exerting market power when purchasing wheat and barley; and other food product manufacturers exerting market power when purchasing wheat, barley, oats and triticale' (O'Donnell et al., 2007, p. 349). McCorriston, Morgan and Rayner (1998) provided a good example of the need to take into account the influence of market power on price-setting in food markets. The authors derived a price transmission elasticity that they demonstrated to depend on 'the degree of market power in the food industry and the nature of the food industry's processing technology', highlighting the 'offsetting role of the processing technology and market power in determining the extent of price transmission' (McCorriston, Morgan and Rayner, 1998, p. 185).

Similarly, the Australian Farm Institute (2018) published a report on agricultural RD&E that is strongly supportive of greater collaboration between agribusiness industries and governments to increase agricultural productivity growth. Two of its seven recommendations are that 'Participation in programs which attempt to match innovation and commercialisation culture between public and privately-funded organisations should be incentivised' and 'Australian Government agricultural RD&E agencies should develop and actively encourage collaborative partnerships with large multinational agribusiness companies'.

While there has been some discussion of these issues (Alston and Fulton, 2012; Alston and Gray, 2013), perhaps attention should be given to alternative approaches to financing agricultural value chain RD&E in a collaborative milieu.

## Chain Goods as Outputs from Agricultural Value Chain RD&E

We first explain how agricultural value chain RD&E can be regarded as either a private good, a chain good or a public good. We then consider the crucial question of who should fund such RD&E by comparing the relative merits of public finance and sourcing funds for conducting RD&E from members of such a chain.

Private goods are widely understood to be rivalrous and excludable, and as defined earlier, public goods are non-rivalrous and non-excludable. Lying in the continuum between the extremes are a whole range of impure public goods of which club goods (Sandler, 2013; Sandler and Tschirhart, 1997) are a subset. Club goods are partly-rivalrous and selectively excludable. Griffith et al. (2015, p. 12; 2018) defined the concept of 'chain goods' as a form of club good, whereby people outside a value chain 'are excluded from sharing in any benefits [including spillovers] derived from collective action within the chain unless there is free riding or non-cooperative behaviour'. Agricultural value chain RD&E may be a chain good in circumstances where the identification and adoption of improved tools and technologies by chain members result in benefits, some of which can be captured by other chain members. Examples of chain goods pertinent to the production and marketing of food and agricultural products include grading and certification systems.

Fleming, Griffith and Mounter (2013) argued that members of a value chain need not rely solely on government to fund agricultural RD&E. They explained that a 'chain goods solution' is a subset of the broader 'club goods solution', and is therefore 'an alternative 'collective approach' to public funding, entailing selective excludability'. That is, decisions are made about who should participate in an agricultural RD&E activity and thereby be eligible to receive some of the benefits from it.

This approach is followed here and linked with Swann's (2003) idea of a 'club goods solution' to research funding to argue that a 'chain goods solution' can be a viable means of funding applied research activity. Potential beneficiaries of an agricultural RD&E project can form a 'club' to fund it by combining their resources to conduct agricultural RD&E that provides a positive net benefit[7]. They would also fund a socially profitable project despite not capturing all benefits. The need for public funding of agricultural RD&E would be limited to those socially valuable projects that are unprofitable for chain participants to undertake, either privately or as a 'club'. The implication for agricultural value chain agricultural RD&E is that funding solutions can be developed that allow for various levels of collaboration depending on which parties within and beyond the value chain have a stake in the agricultural RD&E outcomes. The chain goods solution thereby acts as a complementary strategy to

[7] This is not a new idea. Some 25 years ago there was a debate in the United States about 'self-organizing industry investment boards'. See Griliches (1993) and Romer (1993).

private solutions and to public finance solutions. This view accords with the recommendation by Australian Farm Institute (2018) of 'incentivising' public and privately-funded organisations to collaborate.

A chain goods solution comprises two sub-strategies that reveal different incentives to participate in agricultural RD&E projects: a 'whole club solution', requiring a chain governor, and a 'Coasian solution'. The latter entails the application of the Coase theorem to fix an externality. Private solutions to the problem of externalities and chain or public goods are achieved through independent action by members of the value chain bargaining with other members. An increasingly common example of the former is that of a supermarket-led value chain, such as the ASDA PorkLink Chain described by Renwick (2015).

The main challenge facing policy makers responsible for organising the financing of agricultural value chain RD&E in Australia lies in the task of accurately apportioning funding responsibilities among participants in the value chain, and between them and beneficiaries in the wider economy. As noted earlier, the current approach in most agricultural industries in Australia is a pragmatic one that combines best attainable public finance and chain goods solutions. This approach is adopted presumably because numerous factors may influence the optimal allocation, the effects of which are difficult and costly to compute. In particular, many of these factors are not easily quantifiable. Hence, in evaluating agricultural RD&E payoffs to society and value chain participants the Commonwealth government has decided on a simple 50:50 split between industry and public funding.

Such a funding solution is unlikely to be accurate but it can avoid complicated calculations, be cheaper to implement and avoid disagreements among potential beneficiaries and funders. But net benefits from agricultural RD&E to participants in the chain and to society as a whole would be less than optimal if it is very inaccurate, distorting incentives to conduct research.

## Comparing Public Finance and Chain Goods Solutions to Fund Agricultural Value Chain RD&E

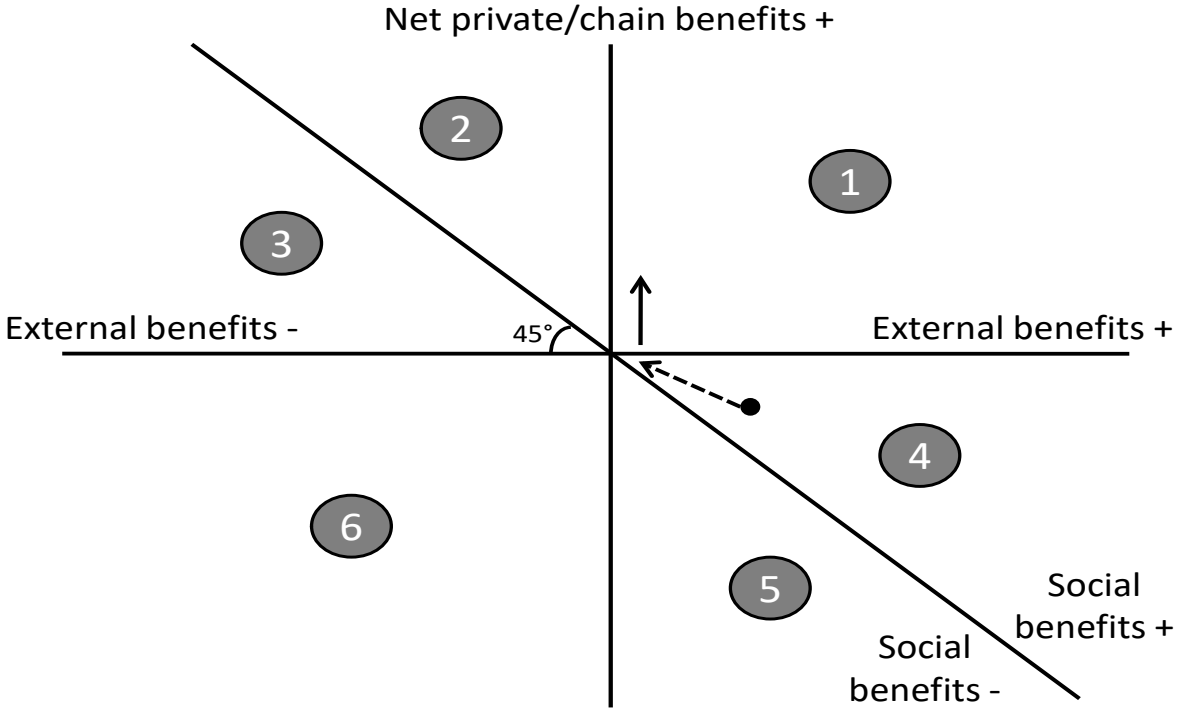
Key criteria for comparing a chain goods solution with a public finance solution can in theory be applied in a manner consistent with the guiding principle of setting the marginal cost of any action equal to its marginal benefit. Swann (2003) provides a basis for comparison by distinguishing errors from rejecting 'a socially profitable project' (that is, not funding a good research idea) and errors of funding 'a socially unprofitable project' (that is, funding a bad research idea).

Before discussing Swann's diagram it is worth noting some contextual issues. First, while his focus is on 'projects', the transactions costs of adopting this type of decision analysis would be very large for individual, especially smaller, projects. Most agricultural RD&E funding is now on the basis of larger research programs. Second, while Swann talks about basic research, it is assumed his approach may be extended to include any applied value chain RD&E where there are uncompensated external effects. Finally, Swann's treatment is similar in many ways to that of Pannell (2008) in the environmental economics sphere. Although the axes are different, both distinguish between public and private benefits and both seek to develop funding rules for different combinations of outcomes.

Figure 1 summarizes the range of possible net internal and external benefits of a research project.

The funding decision for a particular agricultural RD&E project will depend on its location on this figure (Swann, 2003, p. 342). The research project marked by a dot in area 4 of Figure 1, for example, is socially desirable (positive external benefits) but unprofitable to the entire chain (negative private benefits), even though it may be profitable to some individual participants in the chain.

**Figure 1. Net internal and external benefits of an agricultural RD&E project**




*Source*: Adapted from Swann (2003, p. 344).

Projects in area 1 and area 6 of Figure 1 are clear-cut. Area 1 has both positive private benefits and positive external benefits (therefore fund), while area 6 has both negative private benefits and negative external benefits (therefore do not fund). For projects in area 1, the ratio of private to public benefits would provide guidance about who should fund.

Areas 2 and 5 are slightly more complicated. Projects in area 2 should be funded, and will be unless external parties successfully lobby government agencies not to do so. Projects in area 5 should not be funded, but may be funded if external parties successfully lobby government agencies to provide finance.

Areas 3 and 4 are problematic. Projects in area 4 should be funded on social benefit grounds but will not be privately funded by the chain or private members of the chain. Those in area 3 should not be funded on social benefit grounds even though they will appear to be privately profitable.

The position of an agricultural RD&E project on the figure depends on where the boundary is drawn between the internal and external environments. If the funding 'club' were enlarged beyond the value chain and additional chain goods were provided, the project situated in area 4 in Figure 1 would move in a north-westerly direction. But there are complications, which are discussed in the next section. In particular, transaction costs will accrue and the realized internalization converges towards the 45° line, and an increased ability to extract rents shifts the position of the project into area 1.

These complications occur because the public finance and chain goods solutions are both imperfect. In the spirit of Wolf (1993), the relative merits of public finance and club/chain goods solutions to agricultural RD&E need to be judged as a 'choice between imperfect alternatives'. The framework outlined above is helpful but conflates a number of factors (Swann, 2003); therefore, it is important

to compare public finance and chain goods solutions on additional criteria. These criteria are now considered and can be described as 'moderating influences' (Fleming et al., 2013) that corrupt the simple, deterministic equi-marginal principle.

## Confounding Factors Influencing Agricultural Value Chain RD&E Investment Decisions

Deciding who should fund each agricultural RD&E investment, and what proportion they should fund, is confounded by: (1) the distorting effects of a complex environment in which the investment takes place; (2) unequal distribution of benefits and costs that reflect the extent of mismatch between beneficiaries and funders; (3) the impact of transaction costs; and (4) susceptibility of each investment to rent seeking. Public finance and chain funding of agricultural RD&E are unlikely to be equally susceptible to these influences; neither is each proposed agricultural RD&E project likely to be equally susceptible. Hence, each project would need to be judged on its individual merits.

### Accounting for complexity in the decision-making environment

Swann (2003, p. 340) observed that public decision making is more complex than private or club decision making. Complexity has a confounding influence on both public finance and chain goods solutions, but it is more prominent in the public finance arena where there is a greater variety of competing demands for funding. Because of the complex decision-making environment, some funding of socially unprofitable projects can occur arising from inaccurate calculation of private and social costs and benefits, which can be very difficult to quantify, and asymmetric information that creates uncertainty surrounding policy interventions. Complexity engenders opacity that leads to a failure to select socially profitable projects when valuing some non-market social benefits, which are especially difficult because of their subjectivity. This problem is more common in the public finance solution where there is greater need to put values on non-market variables.

The stochastic nature of the agricultural RD&E process is made more uncertain by the need to forecast future outcomes in agricultural value chains where demand and supply uncertainties are prevalent. Public sector administrators are likely to be less able to anticipate future changes in a value chain than their counterparts within the chain, and therefore be more prone to failing to recognize projects with high future payoffs. For an example in meat markets, see Fearne (2009, p. 27). However there is a counter argument that public sector advisors may purposefully over-estimate expected benefits to maximise future budget allocations (and compliance costs (Hodges, 1997)).

But a chain goods solution to agricultural RD&E may be made more difficult in two specific sets of circumstances described by Swann (2003). First, innovators in value chains who accumulate insights from diverse knowledge bases may be better suited to seeking solutions to complex problems. Second, chain goods solutions presume stability and familiarity. In contrast, publicly funded research projects encourage disruption of stability and familiarity (Swann 2003). Much depends on the attributes of agencies in the value chain. Pilon and de Bresson (2003, pp. 27-28) discussed how shared history and values, and tolerance for diversity to allow new entrants and ideas, can stimulate innovation.

Stability within an agricultural value chain is thus a 'two-edged sword'. The emergence of agricultural RD&E chain goods is probably of least concern in stable value chain environments, where the most likely beneficiaries are spatially contiguous and when there are few beneficiaries outside the value chain. On the other hand, the value of chain goods is likely to be greater where beneficiaries are not a tight-knit socioeconomic group in the chain, where new and recent entry into it is important and where beneficiaries are widely dispersed (Swann, 2003).

Swann (2003, p. 340) asserted that 'incentives for due diligence are greatest in the private/club setting', which, if true, suggests that there is greater scope for public funding of agricultural RD&E to select socially unprofitable projects. On the other hand, public organizations are more open to the scrutiny of the general public (in principle if not always in practice) than are clubs while decision making in clubs (chains) tends to be more transparent to those within the club (chain) than to the general public. Further, the measurement of private costs within value chains can be difficult where the commercial-in-confidence defence is offered by firms that do not want to publicize their revenues and costs, raising the possibility of funding socially unprofitable projects in chain goods solutions.

Complexity makes the choice of selection mechanism crucial. The public finance solution is especially prone to invalid selection mechanisms that distort the choice of agricultural RD&E projects, especially if there is political interference in the process or if public finance solutions lead to selecting socially unprofitable projects for fear of failing to select socially profitable ones. It is debatable whether this view prevails as strongly these days as public evaluation of research has become more sophisticated, but certainly doubts remain about the efficacy of government selection methods.

**Detecting and overcoming unequal distribution of benefits and costs**

Swann (2003, p. 340) drew attention to the varied ways in which the benefits from agricultural RD&E outcomes are distributed to beneficiaries. He referred to the matching of beneficiaries and funders as the 'efficient composition' of agricultural RD&E where the funding approach includes whom it should and excludes none who would benefit. However, the efficient composition ideal is very difficult to achieve.

Fleming et al. (2013) pointed out that benefits from agricultural RD&E in value chains are more consistent with an epidemic diffusion process than with a probit one.[8] Value added and its apportionment among participants within the chain can be more easily estimated in the former case. Appropriating funds from those in the value chain who benefit from agricultural RD&E outcomes can be achieved through levies based on additional value created, but doing so will be difficult in many circumstances. For example, consider a meat value chain where the raw material is produced by numerous smallholders and collected, processed and wholesaled by numerous marketing intermediaries. It is difficult to locate the beneficiaries let alone survey them. Internalization while limiting transaction costs will be challenging. This situation is more typical of livestock industries in developing countries than in developed countries such as Australia where there are means by which levies can be collected effectively from producers and the burden of the levy is spread throughout the chain according to the relative price elasticities of demand and supply at each stage (Pindyck and Rubinfeld, 2001, pp. 314-317).

An endemic problem that afflicts both solutions is where agricultural RD&E outcomes lead to a mismatch between the beneficiaries and funders that have equity and efficiency implications. It is especially prevalent for a chain goods solution because of a chain's narrower set of funding sources than public funding solutions. We know that private and social values diverge, a phenomenon that can be extended from private values to the values of chain participants as a group. These participants are likely to be biased towards projects within the value chain that bring them the highest benefits (chain surplus) – regardless of public goods and externalities. To the extent that value chain participants have a particular focus on maximizing chain surplus (Chopra and Meindl, 2013), they are

[8] Swann (2003) noted that a diffusion process is spread in patchwork fashion across the population in a probit process, whereas it is clustered in contiguous or coherent blocks in an epidemic process and the characteristics of actors are similar.

likely to be less aware of social issues (either within or outside the chain) when making agricultural RD&E decisions and therefore more likely to fail to fund socially profitable projects.

There is also a risk of 'free riding' – whereby many beneficiaries of agricultural RD&E outcomes avoid having to pay for their share of the research funds needed – and 'forced riding' – whereby some chain participants have to contribute to funding agricultural RD&E even though it is not in their private interests.[9] On the equity criterion, the free-riding problem characteristic of some (sub-optimal) solutions means that charging those who do not benefit is a common attribute of public finance (Swann, 2003, p. 341). It is much less likely for a chain goods solution but could occur if forced riding takes place.

The distribution of benefits from agricultural RD&E outcomes may be substantially affected by the nature of the research and the way in which the relevant value chains are constructed. Arguably, the error of funding a socially undesirable agricultural RD&E project is trivial for basic research, unless the project cost is large, meaning that the public finance solution is preferred on this criterion. A key question then becomes: Are we more concerned about funding basic or applied research in agricultural value chains? For example, the structure of the chain is especially important in two situations common to Australian meat value chains. First, there are many producers supplying the raw materials that enter the meat value chains. Second, the processing and retail stages of Australian meat value chains tend to be highly concentrated, with dominant roles played by major brands, especially the two major supermarket firms.

The issue of forced riding imposed on producers is a sensitive issue. Griliches (1958, 1971) argued that producers do not necessarily gain substantially from agricultural RD&E if the price elasticity of demand for products they supply is low: rightward shifts of the supply function from agricultural RD&E would result in a fall in total revenue when the price-depressing effect outweighs the positive effect of increased supply. Duncan and Tisdell (1971), Jarrett and Lindner (1977) and Sarhangi et al. (1977) criticized and built on the original thesis posited by Griliches (1958, 1971) and it was generalized for econometric estimation by Peterson (1967). They pointed out that who gains and who loses from agricultural RD&E depends on the nature of both the demand and supply curves and the type of shifts in these curves induced by research outcomes. One possibility is that if the demand for the agricultural raw material entering a value chain from farms is price-inelastic, the introduction of an improved technology in a chain may reduce the economic rents paid for scarce resources in raw material production as Griliches (1958, 1971) argued. But Duncan and Tisdell (1971), Jarrett and Lindner (1977) and Sarhangi et al. (1977) showed that this need not be the outcome in all circumstances.

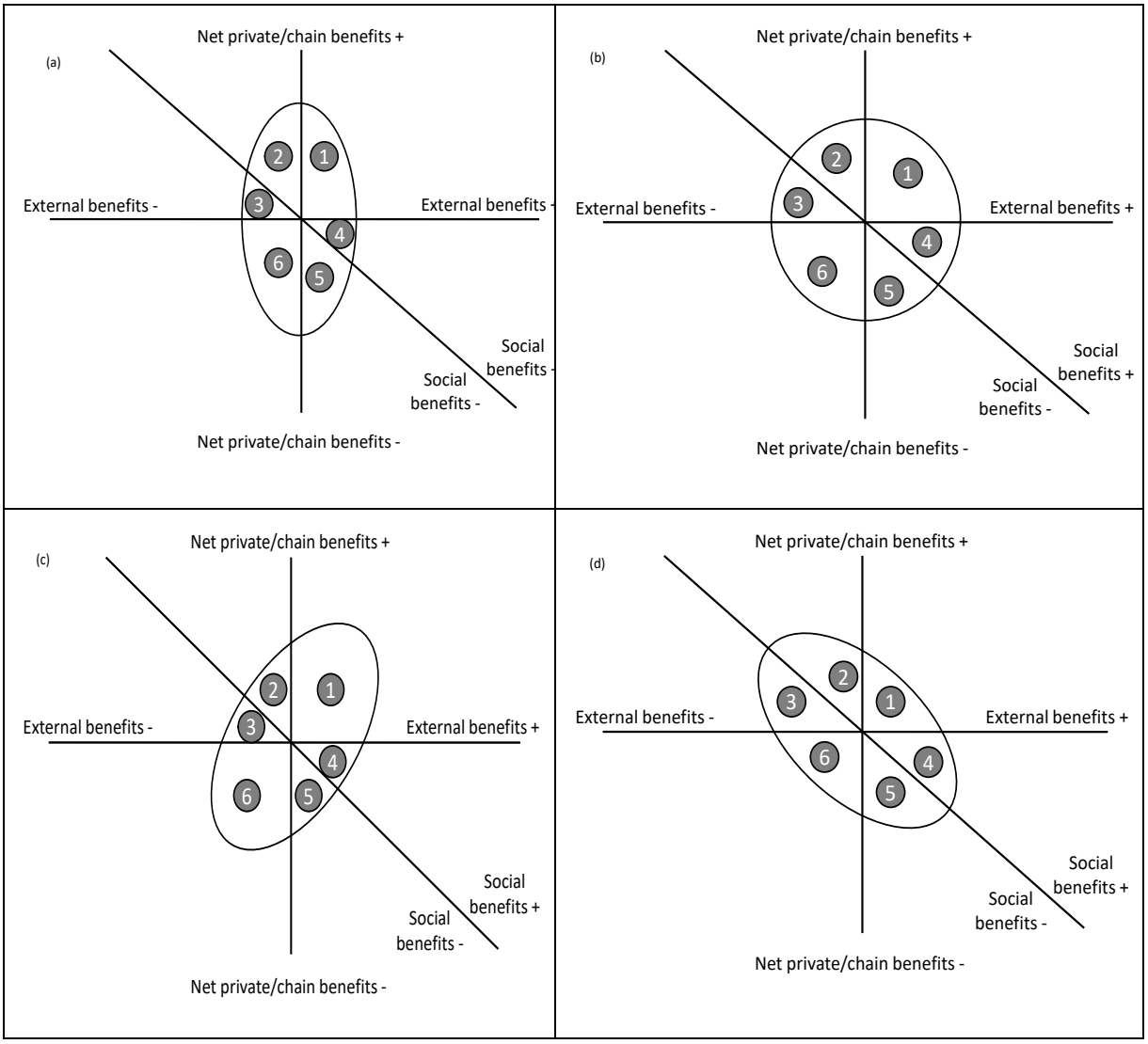
Another source of forced riding is if the levies paid for by producers, along with other chain participants, are used for agricultural RD&E that results in the benefits of these technologies being highly unevenly distributed among chain participants. RD&E in a value chain may thus be counterproductive from a private participant's viewpoint even though it benefits the whole chain, and the transaction costs generated in attempting to correct for such an unequal outcome may be high.

[9] As a reviewer pointed out, a crucial issue is the distribution to participants over time. Our discussion assumes a single policy and its outcome, whereas many policy outcomes will occur over time. The implication is that 'forced riding' may not benefit all participants in a single period but all may benefit over the course of several periods.

The degree of appropriability of knowledge generated by agricultural RD&E[10] also significantly affects the extent of mismatch between beneficiaries and funders. It varies markedly across a value chain, being low in agricultural production and high in the supply of many farm inputs (through the use of patents) (Pray and Umali-Deininger, 1998), and variable across the value chain beyond the farm.

The seriousness of the difference between chain good**s** solutions and public finance solutions depends on their joint distribution. Figure 2 shows four types of distribution that might be relevant (Swann, 2003): (a) high rate of internalization;[11] (b) variable returns and variable internalization; (c) positive correlation between internal/external; and (d) negative correlation between internal/ external.

**Figure 2. Four different patterns of distribution of agricultural RD&E benefits**




*Source*: Swann (2003, p. 346).

[10] Appropriability of technological advances affects the attribute of excludability in distinguishing between private and chain goods, on one hand, and public goods, on the other hand.

[11] Internalization refers to the capture of external benefits flowing from agricultural R&D outcomes by producing chain and public goods.

Where the problem areas are substantial, failures in chain goods solutions will also be substantial. In practice, Swann (2003) noted, the rate of internalization varies considerably and it is not obvious that internal and external benefits will be positively correlated. A key issue is the extent to which the rate of internalization varies across applied research projects in agricultural value chains. There is a need to explore the factors influencing internalization.

A further consideration is whether the benefits from agricultural RD&E undertaken in Australia flow to Australians or overseas. It is commonly assumed when examining the impacts of chain goods on economic surplus that export-oriented industries face a perfectly price-elastic demand function. Where this is so, and research benefits are captured within the value chain, there is no leakage of surplus overseas. However, if this function were to be less than perfectly price-elastic, there will be some leakage depending on the elasticity value. Even if demand is price-elastic, research benefits may be eroded by competition and not significantly benefit those chain participants who initially invested in the agricultural RD&E activity (Griliches, 1993, p. 391).

**Taking transaction costs into account**

Transaction costs affect both public finance and chain goods solutions (see the dotted line with an arrow in Figure 1). High transactions costs deter chain participants from signing up for an agricultural RD&E project because free-riding is made easier when it is costly to locate and charge many potential beneficiaries, particularly if little is known about the extent of their benefits before the project is undertaken (Swann, 2003, p. 340). Political transaction costs can be substantial in a public finance solution even if the logistical costs associated with raising revenue through taxation are relatively small (Swann, 2003, p. 341).

Governments will sometimes intervene to help a value chain lower its transaction costs. An example is where a government provides an incentive for chain members to participate by contributing part of the research costs, such as the cooperative research centres in Australia that are a strategic alliance of private industry, research institutes and government agencies (CRC, 2012). The value chain also benefits from the exploitation of scale economies in research effort when alliance membership is increased.

The economics of funding agricultural RD&E in a value chain can be summarised from Swann (2003) in respect of low and high transaction costs. It is not necessary to assume that all members will participate in an alliance to undertake a research project. If transaction costs – and hence the marginal cost of increasing the number of chain members in the alliance – are relatively low, consistent with an epidemic diffusion process, the profit-maximizing alliance is large relative to the ideal. If transactions costs are relatively high, corresponding to a probit diffusion process, the profit-maximizing club is small relative to the ideal. Differences in transaction costs illustrate two key points made by Swann (2003) that relate to spillovers, which can be extra-chain spillovers (actions of firms and individuals in the chain affect those outside the chain) or intra-chain spillovers (affecting other participants within the chain). First, the extent to which spillovers outside the value chain can be internalized depends on the 'spatial' distribution of the beneficiaries, where 'spatial' is used in a socioeconomic as well as geographical sense. Second, the achievable rate of internalization of spillovers depends on the precise character of the diffusion process. In sum, transaction costs are likely to be larger for the chain goods solution, but there may be large political transaction costs associated with the public finance solution.

**Avoiding rent-seeking**

Rent-seeking commonly accompanies the internalization of externalities and the production of public goods. The impetus for it to occur is the presence of incentives that differ from those that lead to socially optimal behaviour. It arises from a decoupling of beneficiaries from those who pay the costs of interventions aimed at meeting the need of those beneficiaries (see above), resulting in internalities. The term 'internalities' refers to non-market or government failure (Fleming, Heinecke and Dollery, 2007) and was first coined by Wolf (1993) who posited that government intervention in market operations creates costs to society. Internalities are the non-market equivalent of externalities where individuals working in the non-market sector, such as employees in government agencies, divert the use of resources to satisfy their own goals which diverge from social goals.

Public financing is particularly prone to internalities, leading to socially unprofitable projects being funded at the expense of more socially profitable projects. Resources are used up in capturing funds for these projects. There is scope for lobbying by interest groups that can distort the agricultural RD&E project selection processes in both solutions, but it is likely to be especially strong where government agencies are involved in selecting agricultural RD&E projects.

But it might also be strong in some value chains that exhibit conservatism and are susceptible to capture by incumbents who resist new developments that threaten their competitive position. For example, some (usually larger) participants in meat value chains may generate internalities by using the outcomes from agricultural RD&E to strengthen their competitive position, enabling them to exploit their market power to extract rents by exerting control over their intellectual property. A value chain is more able to extract rents from exclusive control of its intellectual property as internalization increases its market power. This would encourage value chain participants to engage in agricultural RD&E projects that might otherwise not be worthwhile. But some research work may not be undertaken and competition in the meat value chain may be weakened if benefits are not widely available to all participants (Swann, 2003).

## When to Resort to a Public Finance Solution

Swann (2003) concluded that there are two broad sets of circumstances in which public finance is preferable to attainable club (chain) goods solutions. The first situation is where the ideal club (chain) goods solution converges to the public finance solution but is costlier to implement. The second is where transaction costs are high and the only viable club (chain) goods produce undesirable solutions. These circumstances are more common in respect of basic research but could still apply in some situations involving the sorts of applied research projects undertaken in agricultural value chains. We focus on convergence first before turning to the issue of high transaction costs.

### Convergence between a chain good solution and public finance

One circumstance of convergence is where spillovers from research are widely dispersed and entail both extra-chain and intra-chain spillovers, most commonly in projects conducting basic research. In this case, it is hard (and expensive) to assemble a suitable 'club' within a meat value chain, or to rely on chain members, because to do so presumes some *ex ante* knowledge of where these beneficiaries are located and the scale of the benefits to each of them. This sort of 'chain failure' arises when benefits are uncorrelated with obvious firm characteristics (such as chain membership) or when it is hard to see how anyone would wish to make use of the products of the research project (Swann, 2003).

Another circumstance of convergence, according to Swann (2003), is in a very complex economy – the Australian economy would be in this category. Many firms and individuals may benefit indirectly from

a research project, even if they are not direct beneficiaries. In a simple economy, on the other hand, the beneficiaries of an agricultural RD&E project are easier to identify and transaction costs of including them in the membership of the agricultural RD&E process and getting them to contribute to its funding are likely to be lower.

A third circumstance of convergence, according to Swann (2003), is when all taxpayers benefit, and benefits are positive and in proportion to tax paid. Leakages of benefits from the value chain are obviously going to be very high (that is, the excludability attribute of a chain good is low or absent). A variant is where internal benefits are perfectly (or at least close to perfectly) correlated with external benefits. Areas 3 and 4 in Figure 2 are very small in this circumstance, and the chain goods solution is at odds with public finance. In a largely export-oriented industry like the Australian red meat industry, many consumers who benefit live overseas while many Australian taxpayers receive little benefit.

**High transaction costs**

Public finance is preferable to any attainable chain goods solution in relation to transaction costs under the following three broad scenarios (Swann, 2003, pp. 353-355). First, transaction costs are high and the only viable chain groups are small, excluding many beneficiaries of research. Second, attainable club (chain) good solutions are too exclusive. Third, excessive closure associated with a value chain reduces technological variety. There is another area of concern with clubs in general and probably value chains in particular. Consider the example of research into setting meat quality standards. There is strong pressure in the standards community to restrict membership to leading players in the interests of securing rapid convergence on an accepted standard. Such leading players often reject the involvement of smaller players and customers, on the grounds that their involvement slows down the leading players and is anyway redundant. Swann (2003) warned that we should be sceptical of arguments that larger firms' interests encompass those of smaller firms and consumers.

## A Recommended Approach to Financing Agricultural Value Chain RD&E

The current approach to funding most agricultural RD&E in Australia is a pragmatic one that combines best attainable public finance and chain goods solutions. For example in the red meat sector, Meat & Livestock Australia Limited (MLA), as an Australian statutory authority, is well placed to offer a chain goods solution through its functions of providing marketing and agricultural RD&E services to the cattle, sheep and goat industries. A majority of its funding is derived from levies on livestock sales, and the Australian Government matches this funding for most RD&E (MLA, 2013). Whether this approach encourages Coasian solutions is not known. Certainly, key firms in the red meat value chains foster innovation in other parts of the chain (notably through setting standards and specifications), but whether the resulting agreements are Coasian or club is unresearched.

The presence of MLA as a chain governing agency makes it possible to potentially operate a two-part tariff system (Pindyck and Rubinfeld 2001, p. 385) that comprises a membership fee in the form of a levy, plus payment for specific shared agricultural RD&E services that MLA provides to chain members. By treating the meat value chain as a club and applying a two-part tariff, MLA should be capable of increasing chain surplus and, at least potentially, maximizing it. The advantage of such a tariff is that it enables members of the club to convert latent demand for agricultural RD&E services into effective demand by internalizing a chain good. By collectively paying for those services that suit their goals, chain members are able to enjoy the consumption of agricultural RD&E outputs that otherwise would not have been satisfied. This occurs already for some outputs such as Meat Standards Australia.

Unfortunately, the current arrangement in which the Federal Government pays one-half and an industry levy contributes the other half of agricultural RD&E funding may make practical sense, but is unlikely to accurately reflect the distribution of benefits that are created. Also, our review of the factors influencing decision making on the best way to fund agricultural RD&E in Australia demonstrates that a clear-cut case cannot be made for either a 'best attainable chain goods solution' or a 'best attainable public finance solution'.

Figure 1 provides a basis for outlining the basic funding principles for RD&E activities in Australian agricultural value chains. The initial step is to establish in which area of the diagram a particular project is located. We suggest the following six principles, beginning with those projects where there is a clear interest for members of the chain to take private action and ending with those projects for which there is likely to be only public interest in funding:

1. Consistent with the recommendation by the Productivity Commission (2011), a private goods solution should be selected regardless of whether they are extra-chain or intra-chain spillovers where there is a reasonable expectation that private net benefits from a research activity will be positive – whether for an individual firm or group of firms acting collaboratively.

2. Coasian solutions to RD&E undertaken by value chain participants may assist, but participants often need prodding towards undertaking collaborative actions. A quasi-Coasian solution is selected where a chain governor can negotiate with and nudge individual participants within the chain to collaborate in a research project. An example of such a solution to funding RD&E is found in the Australian wine industry, which facilitates research collaboration through the Wine Innovation Cluster (http://www.wineinnovationcluster.com/).

3. Commercial fee-for-service arrangements should be put in place for the provision of research support services that mainly benefit particular chain members and which would entail forced riding by many chain members.

4. A pure chain goods solution is recommended where a net chain benefit is expected from a research activity and extra-chain spillovers are expected to be outweighed by the transaction costs of governments engaging with the chain-governing agency.

5. A hybrid public finance/chain goods solution should be adopted to fund RD&E activity within an agricultural value chain where a net chain benefit is expected and extra-chain spillovers are expected to be significantly greater than the transaction costs of governments engaging with the chain-governing agency. A decision on the relative contributions of public and chain funding in these circumstances can be approximated using a four-step Delphi process to establish a scoring system operated by the chain-governing agency and the government. In the first step, the probabilities of failure to select socially profitable RD&E projects and the selection of socially unprofitable RD&E projects would be elicited for both solutions. Second, criteria would be identified that may moderate these two types of errors in chain goods and public funding solutions. In the third step, the criteria would be weighted according to their potential to influence the two error types. Finally, the research activity would be scored and matched to a funding process based on deciles (10:90 funding contribution, 20:80 funding contribution and so on).

6. A pure public finance solution is recommended where an RD&E activity is expected to result in a net social benefit but net chain loss, and (a) the ideal chain goods solution converges to the public finance solution but is costlier to implement and (b) transaction costs are high and the only viable chain goods produce undesirable solutions. It may also be required where the RD&E is initially

expected to result in net social and chain benefits but there is a high probability that chain participants will use the benefits gained to strengthen monopolistic positions in the market in the long term.

Some pre-RD&E analysis is needed to provide the information enabling corporations, chain-governing agencies and public agencies to implement these principles in meat value chains. While corporations should be relied on to undertake the necessary assessments of opportunities to capture additional profits from RD&E in respect of the first principle, chain-governing agencies can improve the prospects of such action in respect of the second principle. A major advancement would be steps by these agencies to improve information flow throughout the chain. Another potentially valuable initiative would be to set up innovation clusters. Implementing the third principle would require chain-governing agencies to be established on a commercial basis to provide research support services that encourage private corporations to conduct RD&E. Enacting the fourth principle would require a chain-governing agency to develop value chain models that provide information on the nature of chain failure and its extent, and the conduct of chain-level appraisals of potential RD&E projects designed to overcome such failure. Project appraisals based on benefit-cost principles would also be needed to assess potential RD&E projects that reside in the purview of principle five, but with the scope being expanded to chain and social benefits and costs, and the collaboration of chain-governing agencies and public agencies in undertaking the analyses. The final principle rests with public agencies to identify, design and appraise RD&E projects lying in the normal domain of social benefit-cost analysis.

Where it is considered too difficult, too costly or too risky to judge the distribution of benefits and costs of an agricultural RD&E activity, the current Australian system of a 50:50 split between the national government and the value chain may be a reasonable compromise despite its shortcomings.

## References

Alston, J.M. (1991), "Research benefits in a multimarket setting: A review." *Review of Marketing and Agricultural Economics* 59(1), 23–52.

Alston, J.M. and Mullen. J.D. (1992), 'Economic effects of research into traded goods: The case of Australian wool', *Journal of Agricultural Economics* 43, 268–278.

Alston, J.M., Sexton, R.J. and Zhang, M. (1997), 'The effects of imperfect competition on the size and distribution of research benefits', *American Journal of Agricultural Economics* 79, 1252–1265.

Alston, J.M., Freebairn, J.W. and James, J.S. (2004), "Levy-funded research choices by producers and society', *Australian Journal of Agricultural and Resource Economics* 48(1), 34–64.

Alston, J.M. and Fulton, M. (2012), 'Sources of institutional failure and underinvestment in levy-funded agricultural research', Invited paper presented at the Australian Agricultural and Resource Economics Society annual conference, Fremantle, February 7–10.

Alston, J.M. and Gray, R.S. (2013), 'Wheat research funding in Australia: The rise of public-private partnerships', *EuroChoices* 12(1), 30–35.

Australian Farm Institute (2018), *Enhancing Private-Sector Development in Agricultural Research Development and Extension in Australia*, Australian Farm Institute, Sydney.

Baker, D., Hamza, K., Parker, W., Scrimgeour, F. and Griffith, G. (2016), 'Primary industry chains and networks: analysis of public and private interests', *Systems Research and Behavioural Science.* Available at: http://onlinelibrary.wiley.com/doi/10.1002/sres.2400/pdf.

Bokelmann, W. et al. (2015), 'Contributing to a better understanding of the value chain framework', paper presented at the International Conference of Agricultural Economists, Milan, July 15.

Burch, D. and Lawrence, G. (eds.) (2007), *Supermarkets and Agri-food Supply Chains: Transformations in the production and consumption of foods*, Edward Elgar, Cheltenham.

Chopra, S. and Meindl, P. (2013), *Supply Chain Management: Strategy, Planning and Operation*, 5th Edition, Pearson Education, Inc., Upper Saddle River, New Jersey, USA.

Cooperative Research Centre (CRC) Program (2012), Cooperative research centres: an Australian Government initiative. Available at: https://www.crc.gov.au/Information/default.aspx

Dairy Australia (DA) (2016) *Annual Report 2015-16*, Dairy Australia, Melbourne.

Deloitte Touche Tohmatsu Ltd (2013), *The food value chain – a challenge for the next century*, DTT Ltd, London.

Department for International Development (2008), *Making Value Chains Work Better for the Poor: A Toolbook for Practitioners of Value Chain Analysis*, Agricultural Development International, Phnom Penh, Cambodia.

Duncan, R. and Tisdell, C. (1971), 'Research and technical progress: The returns to producers', *Economic Record* 47, 124-129.

FAO (2015), *Inclusive Business Models – guidelines for improving linkages between producer groups and buyers of agricultural products*, FAO, Rome.

FAO (2014), *Developing Sustainable Food Value Chains – guiding principles*, FAO, Rome.

Fearne, A. (2009), *Sustainable food and wine value chains*, Government of South Australia. Downloaded 5 November 2012 from:
http://www.pir.sa.gov.au/__data/assets/pdf_file/0017/120419/Fearne_Final_Report.pdf

Fleming, E., Griffith, G. and Mounter, S. (2013), 'Applying a 'chain goods solution' to decisions to fund agricultural R&D in the Australian wine value chain', Contributed paper to the 7th Annual Meeting of the American Association of Wine Economists, 26-29 June, Stellenbosch. Downloaded 31 March 2016 from:
http://www.embassyconferences.co.za/media/aawe_abstracts/Fleming_Griffith_Mounter.pdf

Fleming, E., Heinecke, D. and Dollery, B. (2007), 'An analytical framework for assessing the impact of internalities on policy and projects using examples from Papua New Guinea', *Impact Assessment and Project Appraisal* 25, 199-207.

Foreign Investment Advisory Service (2007), *Moving Toward Competitiveness: A Value Chain Approach*, The World Bank, Washington, DC.

Grains Research and Development Corporation (GRDC) (2002), *Final Report: Value Chain Research – Laying the Foundation for Australian Wheatgrowers*, Grains Research and Development Corporation, Canberra.

Grains Research and Development Corporation (GRDC) (2016), *2015-16 GRDC Annual Report*, Grains Research and Development Corporation, Canberra.

Griffith, G.R. (2000), 'Competition in the food marketing chain', *Australian Journal of Agricultural and Resource Economics* 44(3), 333-367.

Griffith, G., Fleming, E., Mounter, S. and Malcolm, B. (2014), *Accounting for Externalities in Agriculture and Food Sector Value Chains and Systems: Chain Failure, Chain Goods and Chain Bads*, Final Report to Meat and Livestock Australia on Project B.COM.1086, UNE Business School, The University of New England, Armidale, July.

Griffith, G., Gow, H., Umberger, W., Fleming, E., Mounter, S., Malcolm, B. and Baker, D. (2015), 'Refocussing on the value chain perspective to analyse food, beverage and fibre markets', *Australasian Agribusiness Perspectives*, Paper 104.
Available at : https://www.agrifood.info/perspectives/2015/Griffith_et_al.pdf

Griffith, G., Fleming, E., Mounter, S., Baker, D., Hartmann, M. and Simons, J. (2018), 'Consciously pursued joint action: Agricultural and food value chains as clubs', invited paper presented at the 12th International Forum on Food Systems Dynamics, Igls, Austria, February.

Griliches, Z. (1958), 'Research costs and social returns: Hybrid corn and related innovations', *Journal of Political Economy* 66, 419-431.

Griliches, Z. (1971), 'Research costs and social returns: Hybrid corn and related innovations', in N. Rosenberg (ed.), *The Economics of Technological Change*, Penguin, Harmondsworth.

Griliches, Z. (1993), 'Implementing a national technology strategy with self-organising industry investment boards – comments and discussion', in M.N. Baily, P.C. Reiss and C. Winston (eds), *Brookings Papers on Economic Activity: Microeconomics, Vol. 2*, pp. 391-399, Brookings Institution, Washington DC.

Heath, R., Perrett, E. and Day, N. (2018), *Value in Value Chains*, Final report on Project V.CAP.0001, Meat and Livestock Australia Limited, North Sydney.

Hodges, H. (1997), *Falling Prices: Cost of Complying with Environmental Regulations Almost Always less than Advertised*, Briefing Paper 69, Economic Policy Institute, Washington, DC. Available at: http://www.epi.org/page/-/old/briefingpapers/bp69.pdf

Horticulture Innovation Australia Limited (HIAL) (2016), *Strategic Plan*, Horticulture Innovation Australia Limited, Sydney.

Jarrett, F.G. and Lindner, R.K. (1977), 'Research benefits revisited', *Review of Marketing and Agricultural Economics* 45, 147-178.

Kaplinsky, R. and Morris, M. (2001), *A Handbook for Value Chain Research*, Institute of Development Studies, University of Sussex, Brighton, UK.

Mallawaarachchi, T., Walcott, J., Hughes, N. Gooday, P., Georgeson, L. and Foster, A. (2009), *Promoting productivity in the agriculture and food sector value chain: issues for agricultural R&D investment*. ABARE and BRS report for the Rural R&D Council. Downloaded 15 March 2016 from: http://www.agriculture.gov.au/SiteCollectionDocuments/ag-food/innovation2/rd-abare-report.pdf

McCorriston, S., Morgan C.W. and Rayner, A.J. (1998), 'Processing technology, market power and price transmission', *Journal of Agricultural Economics* 49(2), 185-201.

Meat and Livestock Australia (MLA) (2013), About MLA. Downloaded 28 October 2013 from: http://www.mla.com.au/About-MLA

Meat and Livestock Australia (MLA) (2015), Innovation insights (red meat innovation support and market research activities). Downloaded 15 December 2015 from: http://www.mla.com.au/Research-and-development/Search-RD-reports/RD-report-details/Develop-New-Products/Innovation-insights-red-meat-innovation-support-and-market-research-activities/2767

Mullen, J.D., Alston, J.M. and Wohlgenant, M.K. (1989). "The Impact of Farm and Processing Research on the Australian Wool Industry," *Australian Journal of Agricultural Economics* 33, 32–47.

O'Donnell, C.J., Griffith, G.R., Nightingale, J.J. and Piggott, R.R. (2007), 'Testing for market power in the Australian grains and oilseeds industries', *Agribusiness: An International Journal* 23(3), 349-376.

Organisation for Economic Cooperation and Development (OECD) (2007), *Moving Up the Value Chain: Staying Competitive in the Global Economy. A Synthesis Report on Global Value Chains*, OECD, Paris.

Pannell, D.J. (2008), "Public benefits, private benefits, and policy interventions for land use change for environmental benefits", *Land Economics* 84(2), 225-240.

Peterson, W.L. (1967), 'Returns to poultry research in the United States', *Journal of Farm Economics* 49, 656-669.

Pilon, S. and de Bresson, C. (2003), 'Local culture and regional innovation networks: Some propositions', in D. Fornahl and T. Brenner (eds), *Cooperation, Networks and Institutions in Regional Innovation Systems*, pp. 15-37, Ashgate, Burlington VT.

Pindyck, R.S. and Rubinfeld, D.L. (2001), *Microeconomics*, 5th edition, Pearson, Harlow.

Pray, C.E. and Umali-Deininger, D. (1998), 'The private sector in agricultural research systems: Will it fill the gap?', *World Development* 26, 1127-1148.

Productivity Commission (2011), *Rural Research and Development Corporations*, Report No. 52, Final Inquiry Report, Productivity Commission, Canberra.

RBB Economics (2014), *Cost pass-through: theory, measurement, and potential policy implications*, A report prepared for the Office of Fair Trading, London.

Renwick, A. (2015), 'From blockades to supply chain integration: challenges of co-ordination in the agrifood sector', Contributed paper to the 59th AARES Annual Conference, Rotorua, New Zealand, 10-13 February.

Romer, P. (1993), 'Implementing a national technology strategy with self-organizing industry investment boards', In M.N. Baily, P.C. Reiss and C. Winston (eds), *Brookings Papers on Economic Activity: Microeconomics*, *Vol. 2*, pp. 345-390, Brookings Institution, Washington DC.

Sandler, T. (2013), 'Buchanan clubs', *Constitutional Political Economy* 24(4), 265-284.

Sandler, T. and Tschirhart, J.T. (1997), 'Club theory: Thirty years later', *Public Choice* 93, 335-355.

Sarhangi, R.F., Logan, J., Duncan, R.C. and Hagan, P. (1977), 'Who benefits from agricultural research? Comment', *Review of Marketing and Agricultural Economics* 45, 179-185.

Soosay, C., Fearne, A. and Dent, B. (2012), 'Sustainable value chain analysis – a case study of Oxford Landing from "vine to dine"', *Supply Chain Management: An International Journal* 17(1), 68–77.

Springer-Heinze, A. (2007), *ValueLinks Manual: The methodology of value chain promotion*, GTZ, Eschborn, Germany.

Swann, G.S.P. (2003), 'Funding basic research: when is public finance preferable to attainable 'club goods' solutions?', in A. Geuna, A.J. Salter and W.E. Steinmuller (eds), *Science and Innovation: Rethinking the Rationales for Funding and Governance*, Ch. 10, Edward Elgar, Cheltenham.

Webber, C.M. and Labaste, P. (2007), *Building Competitiveness in Africa's Agriculture: a guide to value chain concepts and applications*, Report 52461, Agriculture and Rural Development, World Bank, Washington, DC. Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/2401/524610PUB0AFR0101Official0Use0Only1.pdf?sequence=1

Wolf, C. (1993), *Markets or Governments: Choosing between Imperfect Alternatives*. 2nd edition, MIT Press, Cambridge, MA.