The importance of disaggregation for understanding research impacts and modelling adoption

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Abstract:

Most applications of applied welfare analysis to measuring the returns to agricultural R&D still model the shift in supply and adoption patterns at a relatively aggregated level. Some still use mathematical manipulation of the nature of the supply shift to offset suspected aggregation errors.

This paper briefly reviews the issues involved and highlights the importance of a disaggregated analysis to overcome any such expected errors. It is shown that not only does simple disaggregation overcome concerns with mathematical manipulation but it also enhances our ability to better model the adoption of research outputs by separating the applicability of the technology from other factors which influence adoption. This leads to some important insights which facilitate better understanding of the final outcomes and impacts of research outputs.

An empirical application of the proposed disaggregated modelling to an *ex post* impact assessment study of short duration, fusarium wilt resistant chickpea breeding by ICRISAT and NARS partners is used to illustrate some important issues.

It is shown that if the analysis is disaggregated to more realistically represent the applicability of research outputs and adoption using heterogeneous production and decision-making environments the results provide a better understanding of the impacts. This is accomplished by disaggregation based on different categories of adopters as well as differences in their underlying production environments.

In addition the understanding of the distribution of welfare gains between producers and consumers is shown to be significantly different to the results for an aggregated analysis, with some policy implications being different to those drawn in many past studies. For example, even for the situation when the relative elasticity's are such that an aggregate analysis suggests consumers are the primary beneficiaries of agricultural research, a disaggregated analysis reveals that producers who adopt the technologies may gain considerably more than consumers, but this is offset by significant welfare losses for the non-adopting producers.

Keywords: R&D Impact Assessment; Returns to Agricultural Research, Research spillovers.

1 Introduction

In another paper at this Conference Deb et al (2014) have emphasised the importance of understanding and therefore disaggregating many aspects of research impacts which are crucial to the international public good nature of agricultural research. The discussion highlighted the importance of disaggregating to not only individual or groupings of geopolitical boundaries but also to important features of research domains or production environments. This was shown to both improve the understanding of the many complex interactions and lead to better support for the complex nature of international agricultural research decision-making.

In addition to the importance of disaggregation to better understanding the whole research impact pathway, past literature has also demonstrated that aggregated analysis can lead to important aggregation errors. For many years this lead to misguided debate about what was the appropriate mathematical shape of the supply function shift to avoid these aggregation errors. Unfortunately some recent literature still seems to focus on this mathematical manipulation rather than disaggregation and better understanding of the impact pathway to address and minimise possible errors.

This paper reviews this area including past literature and then highlights some of the issues associated with aggregation, demonstrating why caution is required in making decisions about the level of aggregation when estimating the impact of agricultural research and then using this to support decision-making. It finishes with some conclusions and recommendations for guiding this aspect of research impact assessments.

2 A Review of Reasons for Disaggregation

Most accepted approaches for evaluating the potential impact of agricultural research use a measure of the shift in the supply function due to the research as the basis for estimating the welfare gains. It has long been recognised that it is important to use a detailed cost analysis to measure the vertical supply shift rather than the often-adopted approach of using the yield change to estimate the horizontal supply shift which is then adjusted by the elasticity of supply to give an estimate of the vertical shift. In another paper at this Conference Kumara Charyulu et al (2014) provide further evidence supporting the importance of this issue.

In all the early applications an aggregate country level supply and demand framework was used for this estimation, most of these also used a simple closed economy model. Until advances in computer technology, aggregation was as much driven by computational imperatives as any other issue. However, with recent computer technologies these simplifying approaches are no longer necessary. Despite these changes and increased attention in the literature to the potential importance of disaggregating research impact assessment analyses, even now many studies still use very aggregated levels of analysis.

As has been highlighted in Deb et al (2014) and is illustrated in Figure 1, it is important to separate the impact pathway for research into its component parts. This enhances the understanding of this whole process and helps estimate the impacts on economic welfare. It is also important to ensure that the appropriate information is generated to effectively support each particular research decision-making situation. This full understanding of the impact pathway and factors which contribute to this can be regarded as a form of disaggregation. Most past studies have in fact aggregated the key parameters identified in Figure 1, namely f, u, c, r, p, a, x and k into just x and k, the adoption level each year and the vertical supply shift. It is important to consider what the consequences of this aggregation are likely to be for estimation of the welfare gains from research.

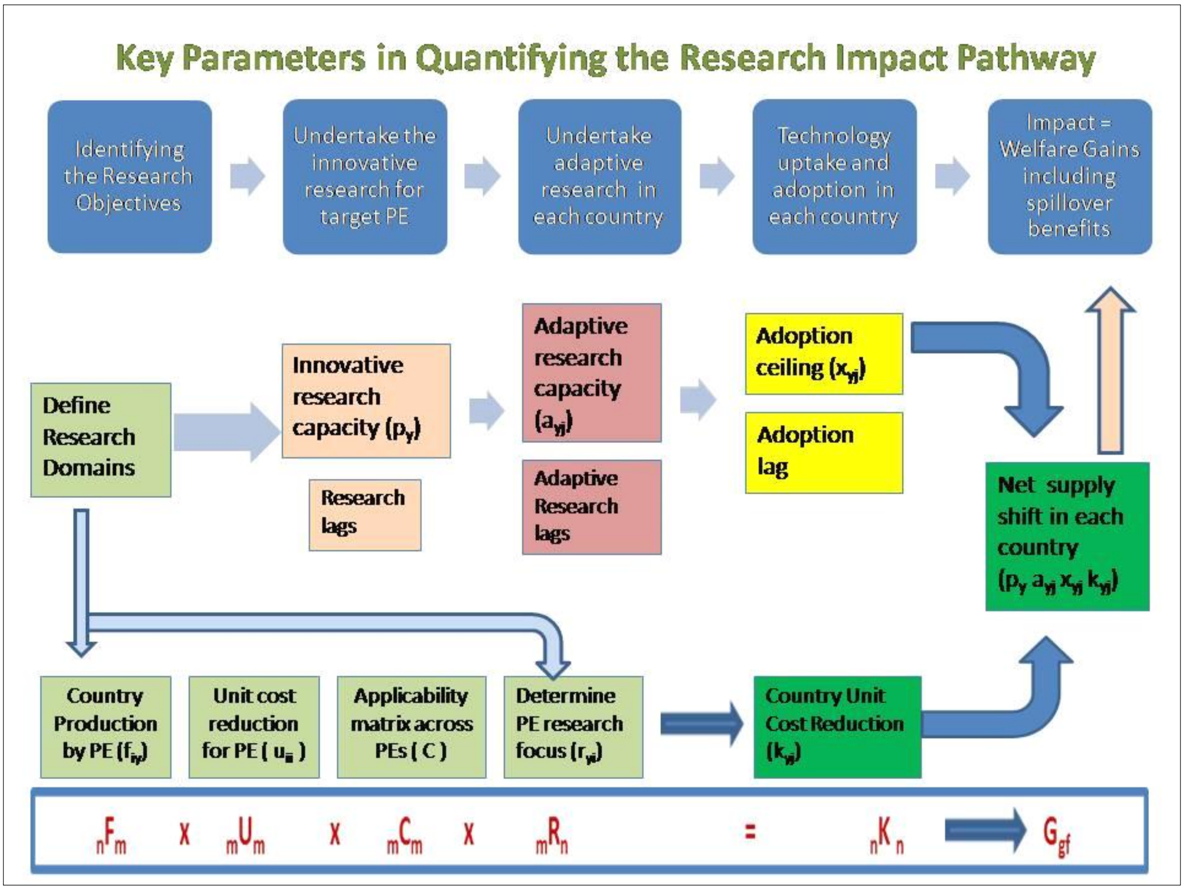


Figure 1: The Impact Pathway and Impact Assessment Framework

From the mid 1970's to the early 1990's there was significant debate about how best to represent the impact of research at an aggregated (usually national) supply level. Much of this debate focused on the mathematical representation of the aggregate commodity supply function before and after the research had generated outcomes. In particular the issues of whether: (i) the aggregate supply curve can be approximated by a linear function; (ii) the impact of the research is best depicted as a parallel, pivotal divergent/convergent or some combination shift in this aggregate supply curve, were the focus of much debate.

Attention was first focused on this set of issues by Lindner and Jarrett (1978). There was a steady flow of papers for about 15 years which addressed a range of associated sub-issues. Examples include Lynam and Jones (1985), Miller et al. (1988) and Voon and Edwards (1991). Davis (1994) reviewed this literature and concluded that the mathematical manipulation discussed in all these papers was misplaced and that the issue is really one of avoiding aggregation errors by better understanding the underlying impacts of research and what drives this. He suggested that in many cases the subsequent studies seem to have ignored an important conclusion which stemmed from the interchange between Rose (1980), Wise and Fell (1980) and Lindner and Jarrett (1980) based on the original work by Lindner and Jarrett (1978). This conclusion suggested that disaggregation "... would involve subdividing the production area into homogeneous regions in terms of the impact of the innovation in question on yield and production costs. Within each region, a parallel shift could be presumed without risk of serious error" (Lindner and Jarrett [1980, p.844]). Davis noted that using especially a pivotal divergent mathematical form was likely to involve significant errors, especially if distributional impacts are important for decision makers using information from the analysis.

It is therefore surprising that many recent studies still choose non-parallel mathematical functional forms at an aggregate level and draw important but potentially incorrect conclusions from them. For example, Alston et al (1995, p.64 footnote 47) conclude that ‘one could always use a pivotal shift rather than parallel in order to generate conservative estimates of total benefits’. Alston et al. (2004) draw conclusions about distributional impacts of research and levies to fund it using aggregated pivotal supply shifts as one illustration. Many other studies still conclude from such aggregate analyses that consumers are the main beneficiaries of research and that ‘farmers’ (implicitly all) may even lose.

It is clearly important to develop a better understanding of the implications of different functional forms and shifts at an aggregate level, especially since some of this work will be important in fully understanding the impact of different types of technology. However, it is also useful to consider in more detail the comments made by Lindner and Jarrett/Rose. A better understanding of their points may provide improved appreciation of the impact of technologies and whether a linear, parallel shift assumption can be shown to be a reasonable approximation in many cases, as then empirical applications will be simpler and therefore the risk of user error reduced. In any case it is important to better understand what the implications of adopting different possibilities might be in different situations.

In Deb et al (2014,and illustrated in Figure 1) it is shown that fully understanding the factors which condition the impact of research is very important, especially to better support different types of research decision-making. Given the diversity of factors which can be important some level of aggregation will be always be necessary. The framework developed by Deb et al (2014) includes various degrees of aggregation using detailed weighting procedures facilitated by matrix manipulation. It is important to appreciate whether some types of aggregation, if undertaken systematically are likely to have large errors and others not. This information can guide practitioners in making choices.

The rest of this paper revisits the discussion by Davis (1994) and assesses the implications for more disaggregated impact assessment studies, not just the choice of mathematical functional forms.

3 A Diagrammatical Illustration of Supply Function Aggregation and Research Impact Assessment

3.1 Introduction

This section considers two aspects of the supply aggregation issue. First, a review is provided of the use of a linear parallel shift as an approximation of the impact of research using a firm level supply function. Second, the potential relationship between a disaggregated analysis and some of the conventionally suggested aggregated supply function shifts is analysed.

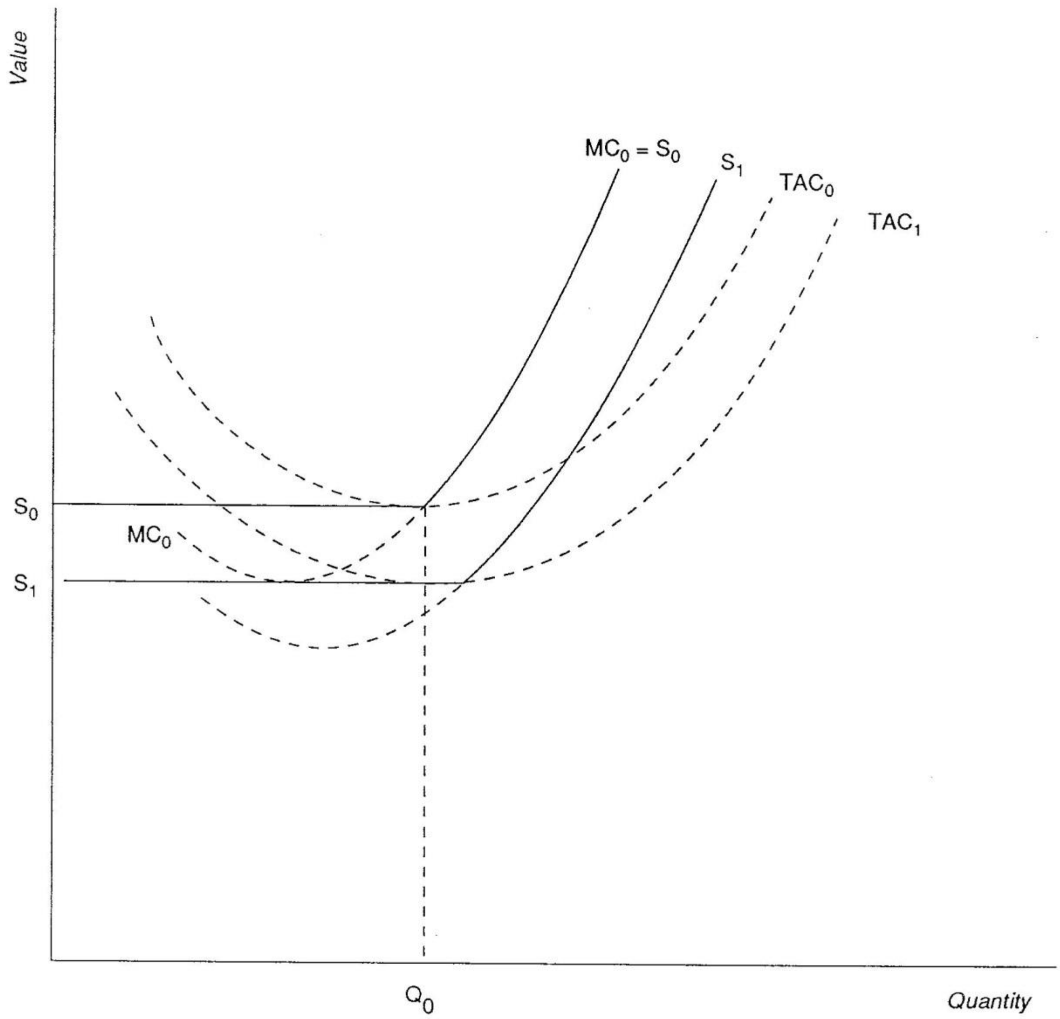
3.2 Cost Curves Aggregated to Give Supply Functions

Standard production and price theory suggests that the individual firm supply function is derived from the firm's marginal and total average cost functions. Figure 2 illustrates. Individual firms will operate where the marginal cost equals the marginal revenue. In a competitive environment the market price will be the firm's marginal revenue. This situation will apply as long as the firm can cover its input costs, thus in the longer term this must be the firm's total costs. In Figure 2 the firm will move along the marginal cost curve (MC_0) depending upon the price faced, as long as the price remains above the firm's total average cost (TAC_0). Below this price, in the longer term, the firm will be better ceasing production. The firm's supply function is therefore represented by the discontinuous function S_0S_0

,with a kink at Q_o. The important feature of this supply function is the linear horizontal segment irrespective of the assumptions regarding the functional form of the cost functions.

If research develops a new technology relevant to the firm, the cost functions will be changed if the firm adopts the technology. The form of these changes will depend upon many factors.

Figure 7.1: ***Firm Costs and Supply Functions***



As shown in Figure 2 if the adoption of research results in a shift in the firm's cost functions and therefore the supply function (to, say, S_1S_1), there are two areas which will represent the welfare gains from the research. The first is an area associated with the horizontal linear segment of the supply function. The second is an area between the marginal cost functions above the minimum total average cost with and without research. The 'before research' firm equilibrium will be at or to the right of output Q_0. It is most likely that Q_0 will be a major share of the equilibrium firm output. If so a linear approximation to the discontinuous supply function and the assumption that the supply shift is parallel may provide reasonable approximations of the research gains. This may be so even if the linear approximation extends into the negative quadrant before intersecting the price axis. A crucial factor in this conclusion is the estimation procedure used to provide the cost impact of the research. If this cost impact estimate is close to the change in the minimum average total costs due to the research, then a good approximation of the horizontal linear component of the welfare change will be provided. Also important, however, is the fact that the use of a continuous nonlinear approximation will not necessarily provide a more accurate approximation of these gains, especially if the linear horizontal segment is the larger area. To date, studies comparing the two estimation methods have not used the actual discontinuous function as the reference.

While this issue warrants further attention it is not the primary focus of this paper. The brief discussion above does, however, suggest that the Lindner and Jarrett/Rose conclusion has some basis, at least at the level of a set of homogeneous firms.

3.3 Industry Disaggregation with a Linear Approximation of Supply Functions

If the firms' supply functions as depicted in Figure 2 are aggregated to the industry level and if all firms faced identical production and cost conditions, then the industry supply will be discontinuous and will also include a substantial linear horizontal segment. Again research which introduces a new technology will change this aggregated firm supply function. If the firms operate in a homogeneous set of production conditions then there will be a parallel shift segment plus a potentially non-parallel shift segment, depending on the nature of the technology and how it influences the production process. A linear approximation at this homogeneous aggregate level may well be appropriate. This is presumably the basis for the Lindner and Jarrett/Rose conclusion.

For the rest of this discussion, the linear approximation conclusion will be accepted;, that is, for homogeneous production regions a linear supply drawn from some current equilibrium position is recognised as a reasonable approximation. If a parallel shift is also accepted then even if the elasticities used infer that the supply intersects the price axis in the negative quadrant the research gain approximation is not affected. This conclusion seems to worry many and it is a puzzle why, since it can be shown that the welfare estimates are equivalent.

Figure 3 represents a single country agricultural commodity situation, which is comprised of three homogeneous production environments suitable for the production of the commodity of interest. There is sufficient variability between the production environments to result in different cost conditions. Each of the aggregated individual production environment supply functions are approximated by a linear supply function. In Figure 3 (a)(b)(c) these supplies are drawn to represent this situation. The national aggregated supply is drawn in Figure 3(d). As is usual it has three kinks at prices sufficient to encourage some production in each region. The demand is drawn only at the aggregate level, although demands may be relevant to each production environment. This is to simplify the diagrams. In the mathematical model, illustrated in Figure 1 and discussed in Deb et al (2014), each homogeneous region (production environment) has its own demand.

Figure 3: Supply Functions Disaggregated for Three Different Production Environments - Case 1: Research Applicable to 'Higher' Cost Producers.

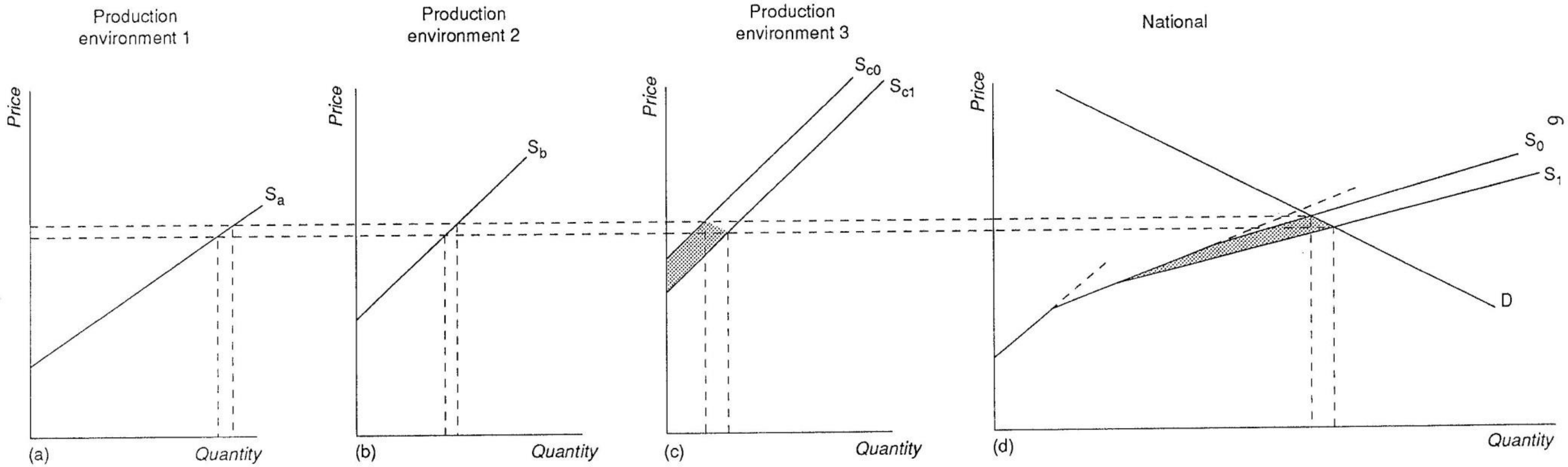
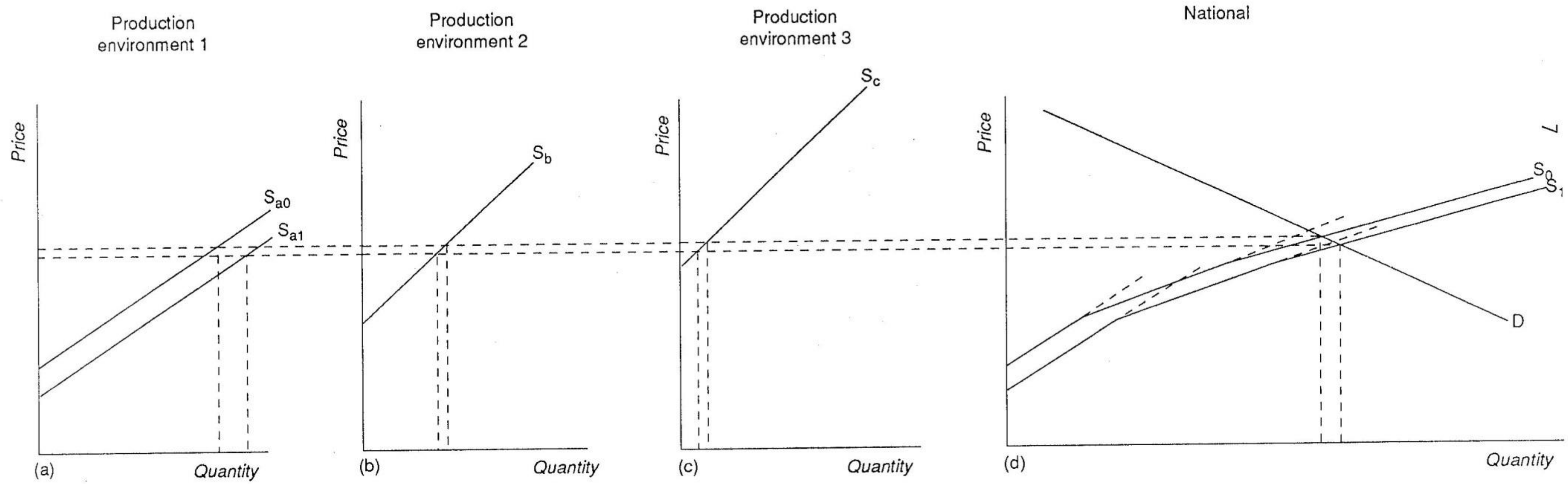


Figure 4: Supply Functions Disaggregated for Three Different Production Environments - Case 2: Research Applicable to 'Lower' Cost Producers.



If research is undertaken related to a production constraint relevant to the higher cost producers in production environment 3 (PE3) and it results in a technology which is only relevant to PE3, then after research only the supply function in PE3 will shift. If this situation is drawn in Figure 3 the aggregate national supply function shifts but only over the top segment. Also notice that the vertical shift in the aggregate supply is smaller than in the underlying PE3 supply shift. This is a result of the aggregation process.

At an aggregate level the approximation of the welfare change will be represented by the shaded area in Figure 3(d). Notice that this area is similar to a pivotal shift representation except that the shift does not pivot from the price axis. Indeed it could well pivot well away from this point. This area can be estimated several ways. One way is to estimate the area between the two supply functions and the changed price line in Figure 3(c) or PE3 where the research was focused. Another is to estimate the changes in consumer and producer surplus in each of the individual regions and then add these surpluses together (some obviously being negative). Either of these two alternative approaches is likely to be simpler than estimation at the aggregate level, which requires accurate information about kink points and aggregation weightings and more complex geometry.

Figure4 illustrates an alternative research focus option. In this case the research focuses on constraints relevant to PE1. The (parallel) shift in Figure 4 (a) transfers through to the national aggregate supply as shown in Figure 4(d). Here, as the other region supplies are aggregated with that from PE1, the shift in the aggregate supply becomes tapered. In terms of the aggregate level representations this shape would be similar to the convergent shift discussed in previous studies.

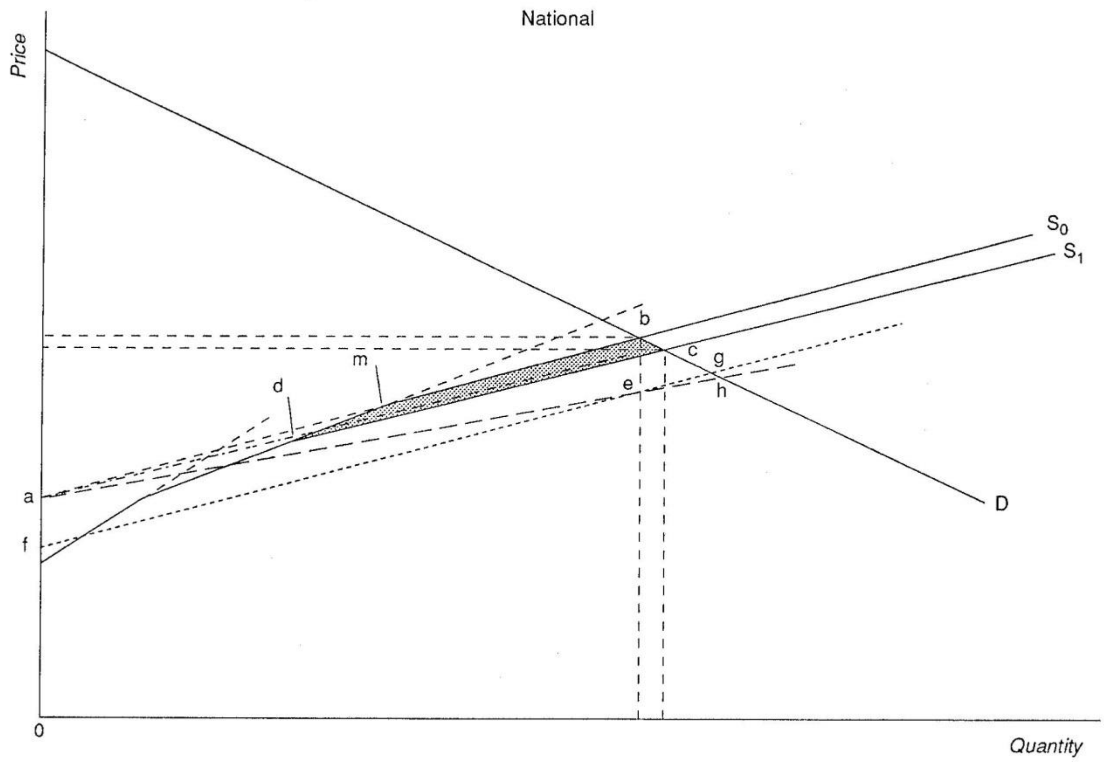
A range of combinations of these shifts and their aggregation can be represented. If the research focused on constraints relevant to PE1 was also partially applicable to PE2 (that is the research has spillover effects), a large range of aggregate representations are possible. Recall all of these are still based on the underlying assumption that the homogeneous level supply shift can be approximated by a linear parallel shift.

Figure 5 combines the aggregated supply functions from Figures 3 with the conventional diagram from other aggregated studies. The previous conclusion that an aggregate parallel shift gives about double the pivotal estimate can be seen, that is, the area 'abgf' compared with 'abh'. A comparison of the disaggregated shift with the pivotal shift highlights some important points.

Clearly the way the level of the supply function shift is estimated becomes crucial. Since many studies use a pivotal shift because it is felt to better represent the differences in adoption, the tendency would be to use the original research impact, that is, 'be' which is, in this case, the full shift in the PE3 supply function. As can be seen, depending upon the underlying research impact, this (implicit) assumption could result in considerable over estimation of the research gains, that is, the area 'abh' compared with 'dmbc'.

This is a potentially important insight as it challenges the suggestion of many that using a pivotal supply shift model provides a conservative estimate of the total welfare gains from research. Depending on the underlying conditions this will not necessarily be the case. On the other hand, if a situation such as Figure 4 applies then using a pivotal divergent model could result in a substantial underestimate of the welfare gains. In this case 'conservative' is a term which needs to be used carefully. Even if an accurate estimate of the adjusted supply shift was available (which would require detailed information at the disaggregated level to effectively estimate) over- or under-estimation could still result. In some circumstances a divergent or even convergent shift could give a reasonable approximation. However, this would require a detailed knowledge of the disaggregated interactions, for example, applicability, cost structures, spillovers, production shares, etc. If this data is available more detailed information would be provided by using it in a disaggregated approach with a parallel linear shift approximation at the individual homogeneous production environment level.

Figure 5: Comparison of Disaggregated and Aggregated Estimation



However, if only the aggregated diagrams are consider and even if the diverse shape of the net welfare change can be estimated accurately, Figures 3 and 4 illustrate how the aggregated analysis masks some very important stories and implications. With a disaggregated framework the simplest estimation approach is to estimate the changes in producer and consumer surplus in each individual disaggregated production environment. This is the approach adapted in Deb et al (2014) but has also been used in most previous multi-region/country models.

For example in Figure 3 this means estimating the change in producer surplus in each of Figures 3 a, b and c. For the first two PE's the technology is not applicable so farmers do not adopt – their existing technology is more profitable that the new one developed for PE3. Alternatively, it might be that the technology is potentially more profitable but some aspect of the environment (political, institutional and infrastructure) facing these farmers inhibits adoption; for example the seed supply system may not be well developed. This discussion highlights the importance of making the distinction between the applicability of a technology to farmers versus potential constraints on their actual adoption. It is important to separate out this applicability aspect from situations when the technology is applicable but a range of possible constraints mean that even if potentially applicable farmers do not adopt. Most past studies have aggregated these different aspects into a single adoption parameter. The discussion in Deb et al (2014) highlights the potential importance of this and the scope for errors to be included in the aggregate estimates of this parameter.

In Figure 4, for the two PE's which do not use the technology the producer surplus is reduced by the areas between the before and after research price lines and the supply and price axis. For PE3 the producer surplus is reduced by a similar amount due to the price fall but this is far exceeded by the increase in producer surplus due to the unit cost reduction and to a lesser extent increased production. The consumer surplus increase due to the lower price is the area between the before and after research price lines and the demand and price axis in Figure 3d.

Importantly the vertical shift in the aggregated supply function will be less than the full unit cost reduction in PE3. This will always be the case unless the research outcomes are applicable to and adopted by a large majority of all farmers. As is illustrated in other papers at this Conference such as Mausch et al (2014), given the nature of many crops and other agricultural products this is rare due to the diversity of production environments where they are grown. What this means is that for those farmers who adopt the technology the producer surplus change will be much higher than the loss due to the price change. This is the case even if the total demand for the commodity is relatively inelastic. This is an important feature of disaggregation and is hidden at an aggregate level, especially if a pivotal divergent supply shift model is used. With this pivotal shift model, if the aggregate demand is relatively inelastic it suggests that 'all farmers' will lose. Based on the discussion and diagrams above this suggests that there is a significant aggregation error when this conclusion is drawn.

This illustration also highlights another important error which an aggregated analysis often generates. This is that consumers eventually receive the bulk of welfare gains as the ceiling adoption level is reached and therefore the price falls by most of the cost reduction the technology generates. As shown above the aggregated supply function shift will not be the same as the shift in the supply functions of the farmers the technology is applicable to (adopters?). Depending on the extent of applicability and associated adoption, the shift in the aggregate supply function could be substantially smaller than the reduction in unit cost of the adopting (applicable) farmers. Even if demand is very inelastic the price can only fall at most by the aggregated supply shift not the full cost reduction. The adopters will still gain significantly via the unit cost reduction the technology provides them.

However a word of caution is required. As is highlighted later, considerable care is always required in drawing conclusions from the distributive impacts of research when these partial equilibrium single commodity models are used. In this case only one technology is considered for one commodity. It is possible that technologies are also developed for this commodity which are applicable to the other production environments. If this happens over time then this applicability difference may mean adopters and non-adopters could be different groups of farmers for each technology developed. For some technologies there will be losers and gainers. Also, as most farmers produce many commodities, what some gain on one commodity technology they may lose on another commodity technology. The important point is that an aggregated analysis hides these issues, which can have important further implications for research resource allocation decision-making.

This result suggests that it is especially important to be very cautious drawing policy implications from the distributive results of any aggregated, single commodity analysis. This especially applies to issues relating to the impact of research on poverty and also the issue of the incidence of levies to fund research.

4. An Illustration - A Case Study of Short Duration Chickpea Research

A recent *ex post* impact assessment study employed a disaggregation approach to estimating the returns to short duration chickpea research undertaken by ICRISAT and its national research system partners. As the analysis proceeded it was found that the original disaggregation raised more questions regarding the nature of the impact pathway and the basis for applicability and adoption of the new varieties of chickpeas that were developed. Eventually, all chickpea producing countries and a range of producers in different production environments were disaggregated into 41 relatively distinct groupings. The basis for this disaggregation include geopolitical boundaries (countries), production environment characteristics (reflecting potential technology applicability) and several important types of adopters, from non-adopters (even when the technology was applicable) to those who switched from other crops to chickpeas on their own or acquired more land because of the relative profitability of the new technology.

The full details of the study are given in Bantilan et al (2014). In this paper we only take one sub-set of summary results to illustrate two of the many important points which were raised in section 3. These are: (i) a simple disaggregation of the results from an aggregated world to two regions: a major producing country (India) and the rest of the world (ROW); and (ii) further disaggregation to separate out adopters and non-adopters. For both illustrations the aggregated supply shift is the accurately aggregated form estimated from the underlying disaggregated individually estimated supply shifts. This is equivalent the shaded aggregated shift illustrated in Figure 5, not the full shift or 'be'.

The study includes many more important insights regarding the impact of the technology. These would not have been uncovered if the disaggregated approach had not been adopted. These are discussed in more detail in the full report and more of the possible aggregation errors identified in section 3 will be included a future more detailed report.

Table 1 presents the summation of the individual estimates of the producer and consumer surplus changes for each of the 41 different combinations of the many production characteristics. These are the individual areas equivalent to those illustrated for the three production environment examples in Figures 3 and 4. The information is summarised for the world and then India, a major producer and consumer of chickpeas, and then the rest of the world (ROW), including developing and developed countries. The full report provides many important additional results and implications for less aggregated sets of the information; for example, the situation for Australia illustrates some results for fast versus slower adoption rates that give different patterns of benefits and losses over time.

In Table 1 two situations from Figures 3 and 4 are illustrated for the three geographical aggregations. The first is the 'aggregated benefits', which is the equivalent of the welfare change areas in Figures 3d and 4d. This is the usual information included in aggregate analyses.

Table 1: Summary Welfare Gains from ICRISAT and Partner Short Duration Chickpea Research.

Welfare Estimate	World	India	Rest of World (ROW)
Aggregated Benefits			
Total Research Benefits	711.7	543.9	167.8
Consumer Benefits	482.9	460.2	22.7
Producer Benefits	228.8	83.7	145.1
Disaggregated Benefits			
Adopter Benefits	606.0	425.3	180.7
Non-Adopter Losses	-377.2	-341.6	-35.6

As mentioned above an important difference though is that they are estimated using the aggregated (weighted) vertical supply shift. This weighting has been developed from the detailed knowledge of the impact over time for the disaggregated 41 distinct groupings of producers. This included differences in the supply function shift (unit cost reduction) estimates for different groups based on survey information. This means that the comparison does not attempt to measure the possible aggregation error from using estimates of the supply shift the way they would be in the conventional aggregated estimation process. Since the understanding of this detail was only really gained from undertaking the disaggregated analysis and further disaggregating as a deeper understanding of the impact pathway was gained, it is difficult to say in hindsight what a conventional aggregated analysis would have used. As was mentioned above, further analyses will be developed and attempts will be made to make this comparison and these will be included in a planned second detailed report for this study.

If we consider the aggregated benefits results in the top half of Table 1, we see that the picture presented is similar to most past impact assessment studies. For the World we see that consumers receive the major share of the welfare changes due to the impact of the research. If the analysis is disaggregated to India and the ROW we see some differences with much lower producer gains in relative terms for India but higher for the ROW. This is not surprising since India is the major consumer in the world and production of chickpeas in the ROW has increased over recent years, partly driven by this technology.

However, when the results of the analyses for producers are disaggregated to separate out adopters and non-adopters a very different story emerges. In this case the non-adopters were a combination of groups of farmers who produce in production environments where short duration chickpeas did not overcome a production constraint. The technology was not applicable to them – it did not perform any better than existing varieties. Others though did not adopt even though the short duration varieties were potentially applicable. In these cases a range of economic constraints inhibited or delayed adoption.

The bottom of Table 1 indicates that the adopters in fact receive a substantial welfare gain – in the case of the aggregated world substantially more than the total for consumers. Even at the simple disaggregated India and ROW levels adopters receive substantial welfare gains, again given the significant level of imports of chickpeas adopters receive a bit less than consumers with, as would be expected, the opposite being the case for the ROW.

However, the position of non-adopters is very important. As expected from the discussion of Figures 3 and 4, non-adopters suffer significant welfare loses. The economic logic to this is clear yet it is surprising that most past studies at the aggregated level have not identified this. Clearly there are many complexities to this story which need to be considered. However, it highlights the importance of considerable care in presenting the aggregate results and especially using them for policy and allocative decision-making support. Some examples of questions raised are: is it mostly poorer groups who are non-adopters? The issue of applicability will be crucial here. What does this mean for issues such as the Australian R&D levy funding system? Some have argued that the justification for the Government providing matching funding is to offset the fact that consumers receive most of the welfare gains from the research. The analysis in this paper suggests the issue will probably be more complex than this.

We expect when we tease out other issues from this extensive disaggregated analysis more important questions will be raised. Again this will be included in the second detailed report for the full study.

7.5. Conclusions.

This paper has reviewed the literature on the importance of disaggregation in research impact assessment studies. It has shown that diagrammatical assessments of the issue suggest that many past studies have focused on mathematical manipulation aspects that may have been misguided.

A recent detailed disaggregated ex post impact assessment study has highlighted that some important aggregation errors or omissions have occurred and these may have led to incorrect conclusions and inappropriate decisions.

The implications are that all impact assessment studies need to look very carefully at the appropriate level of disaggregation which should be employed given the objectives of the study and especially how the welfare benefits generated might be used.

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