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NO. 22 OCTOBER 1990

IMPORT REPLACEMENT AND EXPORT ENHANCEMENT AS OBJECTIVES OF AGRICULTURAL RESEARCH POLICY: INTERPRETATION AND MEASUREMENT[1]

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Philippine Country Study

Collaborating Institutions:

Department of Agriculture (Bureau of Agricultural Research,
Bureau of Agricultural Statistics and the Planning and Monitoring Service)
Philippine Council for Agriculture, Forestry and Natural
Resources Research and Development
University of Philippines at Los Baños
Australian National University

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CONTENTS

1 INTRODUCTION

Public research institutions charged with the responsibility of implementing national and international agricultural research policies face many challenges. Among these is how the limited public funds available should be allocated between what is often a large range of agricultural activities and different geographical or environmental regions. In addressing this decision problem, institution administrators are often required to develop research priorities to indicate the subsets of commodities which are to receive research attention within and between their geographical responsibilities. These priority decisions made by management are usually required as guidelines for research program managers and individual researchers when developing specific research project proposals.

Ideally, the research priorities developed should be consistent with achievement of the research policy objectives set for these public research institutions. With increasing demands for transparent accountability of public sector expenditure, it is becoming important for these institutions to clearly demonstrate that research funding patterns are consistent with policy objectives. It is therefore important to ensure research priorities set by these institutions are also consistent with policy objectives.

In the past, most public research institutions have set research priorities based largely on intuitive judgements regarding potential research impacts. More recently, some institutions have attempted to introduce systematically based procedures to assist research priority decision making. The majority of these attempts have used what have been generally called 'scoring model' procedures. These procedures involve listing a range of important 'criteria' and then having research managers weight and/or score these criteria to provide a ranking of commodities for each region of research focus. The criteria usually chosen include what can be regarded as research policy objectives but also include a range of factors which might be regarded as partial indicators of whether these objectives are being achieved. Since all criteria are weighted and/or scored, it is often difficult to determine what the resultant commodity rankings actually measure. The types of criteria used in these assessments have been many and varied. For example, Oram and Bindlish (1983, p. 55) review fourteen studies and list 30 'criteria' included in one or more of these studies. The number of 'criteria' used ranged from ten to twenty five depending on the study. The conceptual basis for choosing these 'criteria' is rarely discussed and few papers have been published in recognized journals where the methodology used has been rigorously outlined.

On the other hand, an extensive literature has developed during the past three decades which considers in detail evaluation of the impact of publicly funded agricultural research and the resultant technologies. The methodologies developed for these evaluations have been reviewed in detail on several occasions; see, for example, Schuh and Tollini (1979), Norton and Davis (1981), Ruttan (1982) and Anderson and Parton (1983). In most of these studies the appropriate research policy objective has been assumed (often implicitly) to be either to maximize social (economic) gains from research and/or the distribution of these gains to different groups.

Despite the general acceptance of research evaluation methodology by the economics profession there are very few instances where these types of analyses have been incorporated as integral parts of management information support systems by public sector research institutions. Few seem to have asked why, or consider in detail the reasons for this. Possible reasons may include, first, public research institutions often do not have management support staff with sufficient economics training to understand and adapt the methodology to suit their specific decision making environments. Second, the data requirements to successfully complete the necessary analyses are sometimes extensive. For many institutions these data may not be readily available and would therefore be expensive to collect. Another possibility is that many research institutions have multiple research objectives, some of which have not been included in the research evaluation methodology. It is possible that once decision makers recognise this, they conclude that the methodology is inadequate for supporting their decision making environment and reject all uses of this type of analysis. The aim of this paper is to consider in more detail the last of these possible explanations.

Import replacement and export enhancement effects of agricultural research are often given as research policy objectives by public sector agricultural research organizations. For example, of the fourteen studies reviewed by Oram and Bindlish (1983), ten included export earnings and import savings as important criteria in assessing research priorities.

The 'research evaluation' literature has given little, if any, consideration to import replacement/export enhancement types of objectives. There have been no attempts to interpret these types of objectives and develop measures which would provide a systematic basis for providing information to assist decision making. On the other hand, research priority setting efforts which have used the 'scoring model' type approach have often used import–export oriented objectives (criteria) as part of their list of considerations. These studies have not attempted to develop clear interpretations of these objectives or to provide a systematic measure of the potential impact of research as a means of achieving this type of objective.

The aim of this paper is to provide a systematic interpretation of the import substitution and export enhancement types of objectives. Following this, an assessment is made of possible measures which could be developed to indicate to what degree research options might satisfy these objectives. These will be compared with measures available for welfare oriented objectives and the criteria often used in 'scoring models'. A preliminary application to Philippine agriculture is used to illustrate the implications of this analysis and highlight some of the conclusions.

2 INTERPRETATION OF IMPORT–EXPORT TARGETED OBJECTIVES

2.1 Introduction

Development of a systematically based set of information to assist research decision making for any possible objective requires the use of a framework which facilitates comparisons between each alternative objective. An economic framework provides such a comparison medium. This framework also makes use of monetary units of measure which facilitate between commodity and country comparisons. As such it provides a basis for developing measures to indicate whether different research options are likely to achieve the objective specified.

In this section, a set of economic environments which considers different import and export situations will be outlined. The set is then used to develop an interpretation of what import replacement and export enhancement objectives might mean.

2.2 A Description of Alternative Import–Export Environments

2.2.1 Introduction

In any country it is usual to find a range of trading environments for different agricultural commodities. For some commodities, the country will be a net importer, for others production will exceed domestic consumption requirements and net exports will occur. With yet other commodities transport costs or other factors may make trade unattractive, the country will consume all of domestic production and prices will be determined only by domestic production and consumption conditions. For traded commodities it is possible that the country's share of trade is so small that any changes in domestic conditions have a negligible effect on world prices. For other commodities this may not apply and changes due to research impacts might be expected to affect world prices. The latter may also occur if there are research spillover effects to other large producers who do provide a significant share of world trade.

As well as trade in final commodity outputs, many countries also import or export the inputs used in agricultural production. Thus, questions regarding net import replacement or export enhancement may need to be considered. It is likely that non-traded final commodities may also use traded inputs. If so it may be important to consider research on both traded and non-traded commodities when considering these objectives.

With such a diversity of possible economic environments it is important to highlight the main characteristics of each environment as a basis for providing a consistent interpretation of import–export targeted objectives.

2.2.2 Importer — Small Country/No Research Spillovers

With a small country and no research spillover environment, the world and domestic price will be unaffected by potential research on the commodity within the country.[1]

The situation is illustrated in Figure 1. Before research the national supply is represented by S_{n0} and national demand by D_n. The small country assumption means that the country can purchase all import requirements at the ruling world price plus transport costs, P_{wi}, without affecting this price. The world supply facing this country is therefore horizontal at price P_{wi} and is shown by S_w in Figure 1.

Given these supply and demand conditions the without-research quantity produced domestically is given as Q_{s0} and quantity consumed as Q_{d0}. Imports are therefore $Q_{d0} - Q_{s0}$ and the domestic currency required to purchase these imports is $P_{wi}(Q_{d0} - Q_{s0})$.

If research takes place and results in technology which shifts national supply to S_{n1}, then domestic production will increase to Q_{s1} and imports fall to $(Q_{d0} - Q_{s1})$. The change in the domestic currency required to purchase these imports is given by:

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[1] Also assumed in these environments is the absence of other forms of government policy interventions which distort prices and therefore potentially prevent the direct link between world and domestic prices. While the framework can be used to accommodate this environment, its consideration is excluded here to facilitate simpler discussion. This point has been discussed in, for example, Davis et al. (1987, Appendix B).

$$F_{i1} = P_{wi}(Q_{d0} - Q_{s0}) - P_{wi}(Q_{d0} - Q_{s1})$$

$$= P_{wi}(Q_{s1} - Q_{s0}) \quad (1)$$

2.2.3 Exporter — Small Country/No Research Spillovers

Figure 2 illustrates the situation for a country with net exports prior to research having an impact on production. Here S_{n0} is again the pre-research national supply. P_{we} is the export parity price in the domestic currency and D_w is the world demand for the country's exports. This is shown to be perfectly elastic, as expected for a small country situation.

Without research, exports are shown to be $(Q_{s0} - Q_{d0})$ and the total value of these exports in domestic currency terms $P_{we}(Q_{s0} - Q_{d0})$. If the impact of research causes a shift in national supply to S_{n1} then domestic production will increase to Q_{s1}. The change in the value of exports due to research measured in domestic currency is given by:

$$F_{e1} = P_{we}(Q_{s1} - Q_{s0}) \quad (2)$$

2.2.4 Change from Importer to Exporter Due to Research — Small Country/No Research Spillovers

Although not likely to be a common environment, it is possible that research could reduce commodity production costs sufficiently to change a country from a small net importer to a small net exporter. Figure 3 illustrates this situation. An important difference between Figure 3 and Figures 1 and 2 is the inclusion of both the world supply and world demand for the commodity. These are perfectly elastic at the import parity price, P_{wi}, and the export parity price, P_{we}, respectively. The difference is the transport cost differential which reflects the transport cost from the nearest source of import supply and to the nearest destination of export demand facing the commodity for the country.

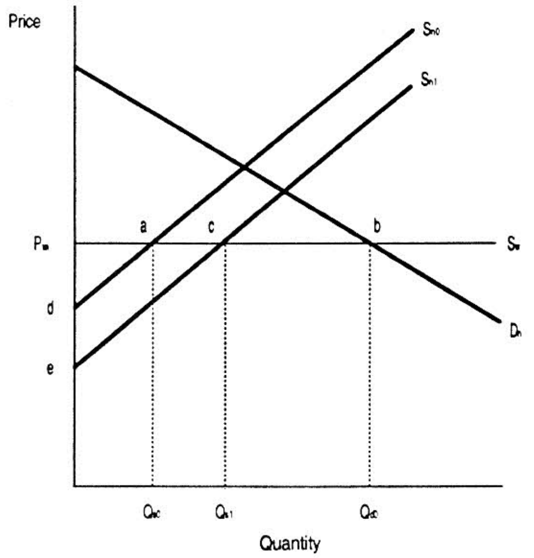

Fig. 1. Illustration of case of net importer, small country and no international research spillovers

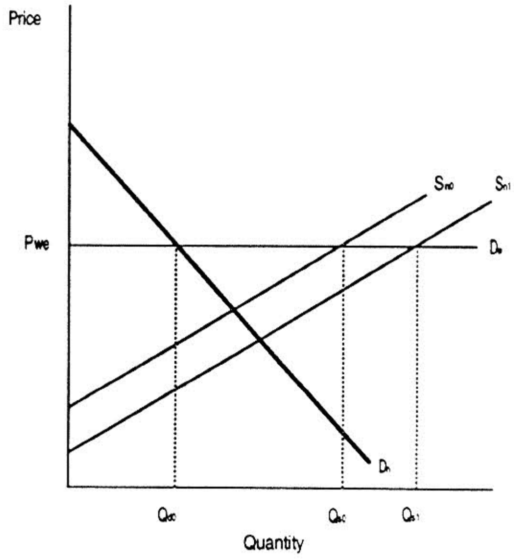

Fig. 2. Illustration of case of net exporter, small country and no international research spillovers

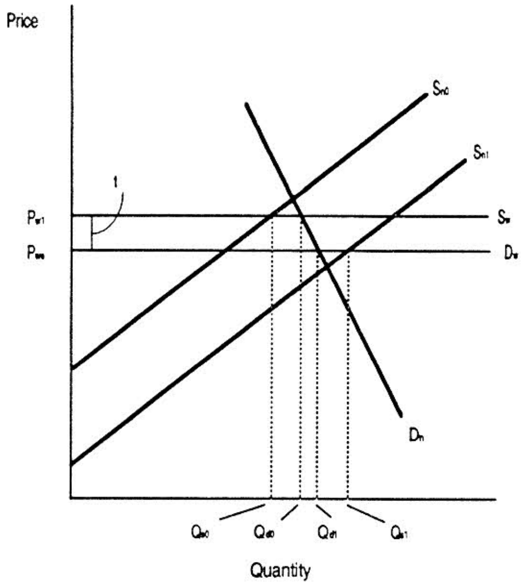

Fig. 3. Ilustration of a case of a change from a net importer to a net exporter due to research

Before research, the country was a net importer of the commodity with imports of $(Q_{d0} - Q_{s0})$. If research results in a shift to Sn1, the country will begin exporting the commodity, with exports of $(Q_{s1} - Q_{d1})$. The change in foreign exchange flows due to the impact of research is given by:

$$F_{c1} \quad = \quad P_{wi}\,(Q_{d0} - Q_{s0}) + P_{we}\,(Q_{s1} - Q_{d1}) \qquad (3)$$

2.2.5 Importer — Large Country and/or Research Spillovers

The economic environments illustrated in Figures 1 to 3 assume that research in the country in question has little potential impact on the world price of the commodity. That is, the output change resulting from the impact of research is very small relative to total world production. There are at least two situations when this assumption is unlikely to be realistic for a country: if the country produces and imports or exports a substantial share of world production of a commodity; and/or if the research results produce technologies which, with adaptive research effort, are applicable in other countries and the combined output of all these countries represents a significant share of world output. In either or a combination of these circumstances the import or export parity price facing the country will change due to the impact of research. It is important to consider how this may influence the pre- and post-research import or export levels of the commodity.

Figure 4 illustrates a simplified representation of the combined large country and research spillover situation. A two country situation is used with country 1 as an exporter and country 2 an importer. Research is assumed to take place in country 2 and have spillover effects after adaptive research to country 1. Notice in this illustration the unit cost reduction due to research (vertical shift in the national supply) is smaller in country 1 than in country 2 where the research originated. Figure 4(b) represents a simplified world market for this two country example. The intersection of the excess supply, E_{S0}, and excess demand, E_{D0}, gives the equilibrium world price, P_{w0}. For simplicity transport costs have been ignored in this illustration. As discussed above this only becomes important if a country switches from an importer to an exporter, or vice versa, due to the impact of research.

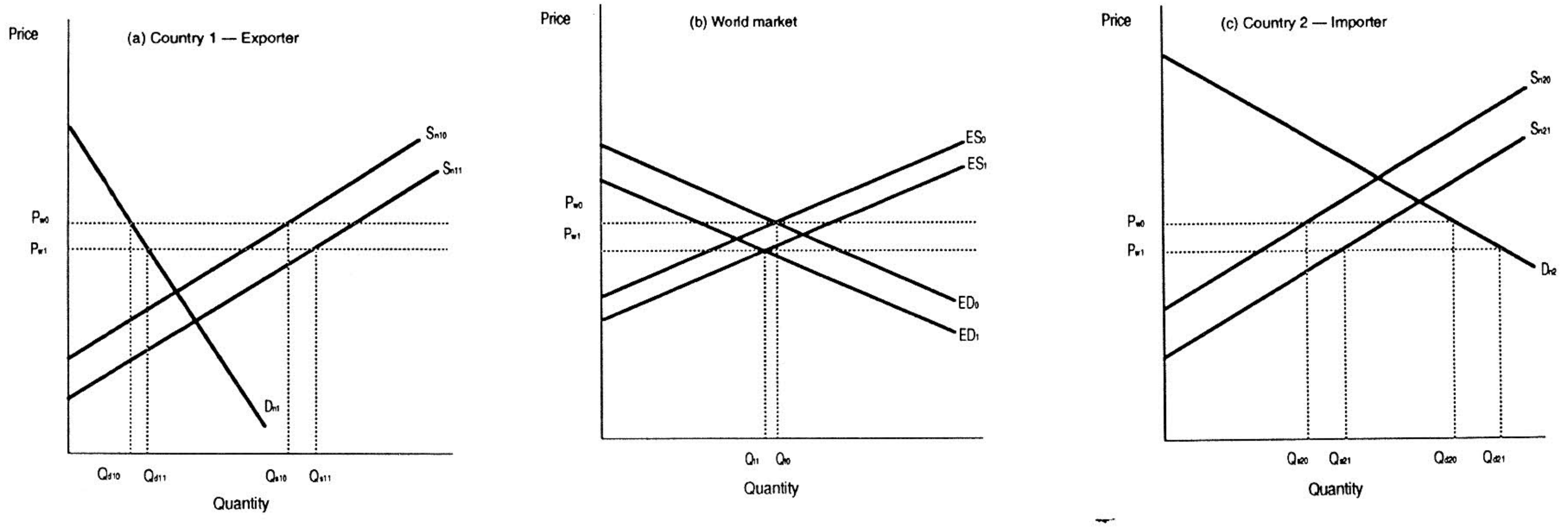

Fig. 4. Illustration of the case of a large country and research spillovers

Figure 4(c) is equivalent to Figure 1 except for the large country and research spillover assumptions. Comparison of areas on these two figures gives an indication of the importance of these changes in the economic environment. Before research the world price is P_{w0} and country 2 imports $(Q_{d20} - Q_{s20})$ of the commodity. Because of the two country illustration we have:

$$(Q_{d20} - Q_{s20}) = (Q_{s10} - Q_{d10}) = Q_{t0}$$

That is, world trade, Q_{t0}, is equal to imports to country 2 and exports from country 1.

After research, supply in country 2 shifts to S_{n21} and, therefore, excess demand in the world market to ED_1. Also, due to research spillovers the supply in country 1 shifts to S_{n11} and excess world supply to ES_1. The research now has potential to result in a change in the world price.

In Figure 4 the world price falls from P_{w0} to P_{w1}. Now both the production and consumption will change in country 2 (and country 1). If the price axes are measured in the currency of country 2, then the change in the value of imports in country 2 is given by:

$$F_{i2} = P_{w0}(Q_{d20} - Q_{s20}) - P_{w1}(Q_{d21} - Q_{s21}) \quad (4)$$

For the situation illustrated in Figure 4, since $Q_{t0} > Q_{t1}$ it can be seen that $F_{i2} > 0$. This will not always be the case. Depending on world production and consumption shares, research spillover effects and elasticities of supply and demand in different countries research could result in increased total values of imports for country 2.

The more diverse nature of the economic and research environment illustrated in Figure 4 also raises other issues. For example, as research spillovers occur only after some adaptive research, there will be a difference between the time to adoption of research for countries 1 and 2. Thus, the shift from S_{n10} to S_{n11} in Figure 4(a) is likely to occur several years after the supply shift in Figure 4(c). In this case, only the excess demand will shift from ED_0 and ED_1 during the intermediate period. An equilibrium world price between P_{w0} and P_{w1} will result, and trade in the commodity will be given by the intersection of ES_0 and ED_1. This will be smaller than Q_{t1}. The value of imports in country 2 will be smaller and therefore the difference due to research will change. The pattern of these changes over time and the choice of discount rate for this type of objective become important issues.

2.2.6 Traded Inputs

The economic environments discussed so far have considered only trade in final commodities. In most economies, several inputs used in the agricultural sector are traded, often imported. If import replacement is a research policy objective, then consideration of the value of imported inputs used may be required. Similarly, if the commodity is exported but uses significant quantities of imported inputs the change in the value of these inputs may be important. The addition of this factor to the environment results in several complex factors becoming potentially important.

Figure 5 provides an illustration of some of the main points. The situation depicted is similar to Figure 4(c). The line C_{20} provides an indication of the share of supply costs at each possible commodity price which is allocated to imported inputs and the share to domestically produced inputs. The area between S_{20} and C_{20} — that is, 'abcd' — indicates the share of total supply costs allocated to imported inputs before research takes place; that is, when national production is Q_{s20}.

After research, the supply shift to S_{21} will be accompanied by a shift of the input cost share line to C_{21}. Ignoring for the moment the relationship between these shifts, the change in the domestic currency value of imported inputs used in production is given by 'abcd' less 'efgh'. The change in the domestic currency value of imports associated with the commodity due to research is then shown by:

$$F_{i3} = P_{w2}(Q_{s1} - Q_{s0}) + abcd - efgh \qquad (5)$$

Whether $F_{i3} > F_{i1}$ depends on whether abcd > efgh. *A priori*, the latter need not be the situation. If the vertical distance between C_{20} and C_{21} is the same as between S_{20} and S_{21} then efgh > abcd. However, this would be an unusual case. It would require that the technology developed by the research would leave the per unit of output use of imported inputs at the pre-research level. The technology would need to result in cost savings only in the use of domestic inputs. This situation clearly places restrictive assumptions on substitution possibilities between domestic and imported inputs, as well as on the nature of the technical change.

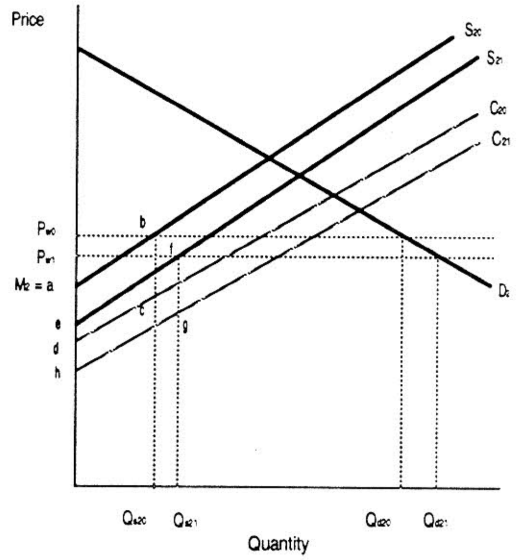

Fig. 5. Illustration of the imported output, imported inputs, small country and international research spillover case

The more likely situation is when the shift from C_{20} to C_{21} is different from the shift from S_{20} to S_{21}. If the technology is factor (input) biased, then the shift could be either greater or less, depending on the direction of the bias. If the technology is factor neutral the shift from C_{20} to C_{21} could be proportional to the shift from S_{20} to S_{21}. However, this would require that input prices remain unchanged, or change in unison. If, for example, imported input prices remain unchanged but domestically produced (non-traded) input prices change, then the relationship between the two shifts will depend on the relationship between the input price changes and input substitution possibilities.

In addition to the size of the shifts in the underlying functions, the price sensitivity of commodity supply will be an important determinant of the size of the net change in the value of imports associated with a particular commodity. Therefore, the elasticity of supply and available estimates of it become a crucial factor in determining the level of achievement of an import–export targeted objective.

In summary, the possibility of both traded final goods and traded inputs makes complex the measurement of how well an import replacement or export enhancement objective is likely to be achieved. Issues such as factor biased technological change become important. Also, simple measures of the current levels or values of imports or exports of final products are certain to be poor indicators of how well these objectives are achieved for different commodity research options.

2.2.7 Non-Traded Output and Traded Inputs

The possibility of an environment where inputs are traded introduces the need to consider non-traded as well as traded commodities. Even if the output is not traded internationally, some of the inputs used in production could be. If so, it is likely to be important to consider changes in the imported value of inputs resulting from research.

Figure 6 illustrates the type of environment that could result. As in Figure 5, research is shown as a shift from S_{20} to S_{21} in the commodity supply. Associated with this is a shift from C_{10} to C_{21} in the input cost share line. Without an import supply (or export demand), domestic price is determined by local supply and demand conditions. Without research, this gives a price of P_{n0}. With research, this will fall to P_{n1}. Output and domestic consumption increases from Q_{s0} to Q_{s1} (which equal Q_{d0} and Q_{d1}, respectively). The change in the domestic currency value of inputs associated with this commodity is given by:

$$F_{c1} = abcd - efgh \qquad (7)$$

Whether $F_{c1} > 0$ depends on the range of considerations discussed in section 2.2.6. The factor biased/neutral nature of possible technologies resulting from the research, share of imported input costs of total production costs and sensitivity of supply and demand to changes in prices are some of the important determining considerations.

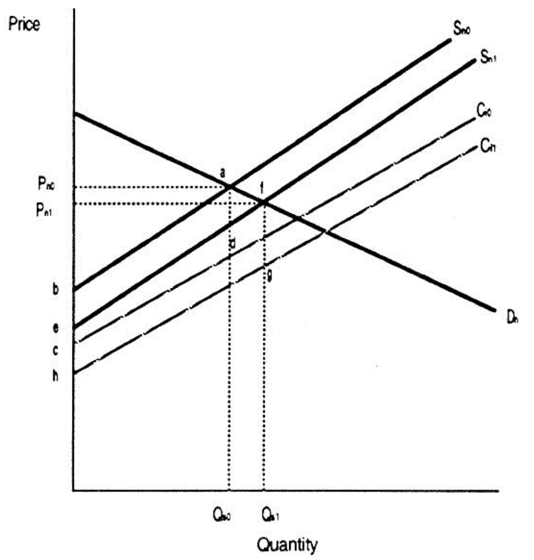

Fig. 6. Illustration of the case of a non-traded output but traded inputs

2.2.8 Other Considerations

In each of the environments discussed above, the exchange rate has been assumed to be given and implicitly that it is determined in a relatively unregulated national environment. In many cases an important reason for adoption of import replacement or export enhancement as an objective of research policy is the foreign debt problems of some countries and the associated government regulated exchange rates. Foreign debt, usually repayable in a major foreign currency, often places pressure on the willingness of governments to allow exchange rates to be determined in a competitive environment. Thus, in many cases, exchange rates are over- or under-valued, and international transactions controlled to maintain this distortion. Persistent foreign debt and pressures from a distorted exchange rate often lead to a view that further government intervention to encourage import replacement or export enhancement is warranted. While this may be defensible in special situations, it can be shown that in most situations the second round interventions only serve to compound the social welfare costs of the initial exchange rate manipulations. Although perhaps unpalatable in the short run it will usually be preferable to eliminate the initial distortions and use social welfare maximization objectives for all public investments.

A simple, small country importer environment can be used to illustrate this point. Figure 7 is the same as Figure 1 where P_{wf} is the import parity price with an unregulated exchange rate environment. If the government develops a regulatory environment that results in an over-valued exchange rate, then the domestic currency import parity price is likely to be P_{wr1}. Thus, imports of the commodity are now, if levels are unconstrained by government policy, available at a lower domestic currency price. In such an environment domestic production becomes less attractive and consumption of imports more attractive. Therefore, imports under unregulated conditions of $(Q_{df} - Q_{sf0})$ will increase to $(Q_{dr} - Q_{sr0})$ with exchange rate controls. Depending on underlying conditions, domestic currency expenditure on imports could increase.

Although an economy wide general equilibrium model is needed to accurately represent this environment, it can be seen from this illustration that short-term exchange rate regulation is

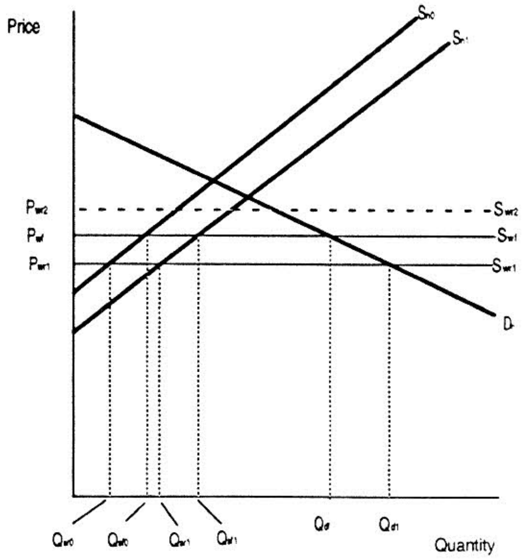

Fig. 7. An illustration of the potential impact of regulated exchange rates

almost certain to lead to longer term self defeat or the introduction of additional regulation of import levels.

If the export commodity environment of Figure 2 is considered, it can be shown that an overvalued exchange rate will result in a lower domestic currency export parity price and therefore a reduction in domestic production and export levels.

The alternative environment of a regulated under-valued exchange rate will have the opposite effects. That is, imports will be lower and exports higher than in a floating or unregulated exchange rate environment. Of course, in this situation foreign debt levels and repayments will, if written in international currencies, be higher.

The shift in supply due to research, that is S_{n0} to S_{n1}, can be incorporated as shown in Figure 7. For the small country/no research spillover case, although the domestic currency value of imports is reduced, the distortions to consumption remain. For the illustration used, the value of imports is still higher than if exchange rate restrictions were eliminated.

2.3 Interpretation of Objectives

The systematic discussion of import–export targeted objectives using a simple supply and demand framework provides a basis for developing a clearer interpretation of this type of research objective. This clarification is required to facilitate development of measures which can be used to indicate whether different research emphasis will achieve this type of objective. In addition, measures derived on this basis can be more readily compared with measures associated with other objectives, for example, national welfare maximisation.

Import replacement and/or export enhancement as a research objective is not a very specific description. Inspection of Figures 1 through 7 suggests a list of possibilities that could be included in these statements. The main possibilities include:

(i) maximisation of the reduction in the gross value of commodity imports or increases in the gross value of exports due to research. This would be measured by F_{i1}, F_{e1}, F_{c1} or F_{i2} depending on the appropriate environment.

(ii) maximisation of the reduction in the net value of commodity imports or the increase in the net value of exports due to research. This would be measured by, for example, F_{i3} or perhaps F_{c1}.

(iii) maximisation of the net value of total welfare gains due to decreased imports or increased exports. This objective would be measured by, for example, the area 'acn' in Figure 5.

The first two interpretations of objectives stem from the discussion of Figures 1 to 7. The third possibility requires brief discussion. Maximisation of an area such as 'acn' may be viewed as appropriate if it is felt that it is inadvisable, when making research resource allocation decisions, to ignore the level of domestically produced resources which are used in producing a commodity. This point may be clearer if the following is considered. The welfare of a country is unlikely to be improved by producing a commodity when the value of inputs used to produce it exceeds the value of the output of the final product. In this respect, areas such as 'acn' in Figure 5 are the net gains to society from decreased imports resulting from research.

However, the latter interpretation of import–export targeted objectives seems to beg the question: why be concerned only about welfare gains on the traded component of production? All welfare gains from research appear to be a more appropriate objective. If this interpretation is accepted there is a strong case for reverting to a national welfare objective and measures of this. Import–export targeted objectives are best subsumed into this.

If, on the other hand, objectives such as (i) or (ii) are specified as crucial to research policy, it is important to develop measures to reflect these and provide comparisons between them and possible other objectives, such as national, or regional welfare improvement. It can be seen from Figures 1 to 7 that research emphasis on some commodities will satisfy one objective more than the other. Thus, import replacement maximisation may require significant sacrifices in national welfare improvement. Information indicating commodities which satisfy both objectives could prove useful for assisting decision making.

3 MEASUREMENT OF IMPORT–EXPORT TARGETED OBJECTIVES

3.1 Introduction

Quantitative measures of welfare maximisation and redistribution objectives have been developed by, for example, Davis et al. (1987). These are based on environment descriptions similar to those included in Figures 1 to 7. Similar measures can be developed to facilitate systematic comparisons between these objectives and import–export targeted objectives. Estimation of generalised versions of equations (1) to (5) provide these measures.

This section provides estimates of these generalised formulae. A comparison with formulae measuring the achievement of national welfare orientated objectives is presented.

3.2 Measures for Import–export Targeted Research Objectives

Norton and Davis (1981) have summarized the range of economic environments used to develop research evaluation measures. All of these environments focused on closed economy models. Edwards and Freebairn (1984) extended the methodology to a traded goods environment. Davis et al. (1987) expanded their basic model to include many trading and non-trading countries and placed more emphasis on the concept of research spillovers between countries (regions) and factors such as the adoption characteristics and differences in adaptive and innovative research strengths between countries (regions). Davis et al. (1989) have focused attention on the importance of modelling between region research spillovers and have suggested some systematic procedures to do this.

Combined, the developments in these studies can represent most aspects of the economic and technical environments included in Figures 1 to 7. The underlying model used to find measures for national welfare oriented objectives can therefore be used to develop measures for assessing import–export oriented objectives. To simplify presentation, several aspects of the previous models will be ignored. These include differences in adoption of the technologies and differences in innovative and adaptive research strengths between countries. Formulae developed will not include time flows and discounting factors. As can be seen from, for example, Davis et al. (1987), these parameters can be added with only minor adjustments and are not crucial for highlighting the main points of focus in this paper.

Formulae for several different measures associated with import–export targeted objectives are developed below. These include measures of: the gross value of current imports or exports; the change in the value of commodity imports or exports due to research; the change in the value of imported inputs due to the impact of research; and the expected gross national benefits from research and their distribution between producers and consumers in the country where research takes place. The latter group of formulae is taken from previous studies and is repeated here using consistent terminology to facilitate comparisons.

3.2.1 Gross Value of Current Imports or Exports

The most common measure of an import–export objective used in 'scoring model' studies is the gross value of current imports or exports. From most of the figures discussed earlier it can be seen that this can be measured as:

$$GVT_{i0} = P_{w0}(Q_{di0} - Q_{si0}) \qquad (8)$$

where:

GVT_{i0} is the gross value of trade for the commodity of interest in country 'i' at pre-research price and output levels;

P_{w0} is the world price of the commodity under pre-research equilibrium conditions;

Q_{di0} is the domestic consumption of the commodity in country 'i' before research; and

Q_{si0} is the domestic production of the commodity in country 'i' before research.

It is readily seen that this 'scoring model' type of measure of the achievement of import–export oriented research objectives is not dependent on any of the changes in the technical and economic environment after research has an impact on production. In most countries, reasonable estimates of the information required to calculate this measure are available. This probably explains its regular use in 'scoring model' assessments.

3.2.2 The Change in the Value of Commodity Imports or Exports as a Result of the Impact of Research

Equation (4) is the general form of a measure which indicates the change in the value of commodity imports or exports as a result of research undertaken in a particular country. It has been shown, in the research evaluation literature, to be useful to express these measures in terms of pre-research equilibrium conditions and research impact parameters. Davis and Bantilan (1990) provide details of the substitutions and term rearrangements required to provide the following formula:

$$CVT_{qi} = \varepsilon_{si} Q_{si0} k_{ii} \{[Q_{di0} - Q_{si0} - (\varepsilon_{si} Q_{si0} k_{ii}/P_{w0})] - (\varepsilon_{si} Q_{si0} + \varepsilon_{di} Q_{di0})$$
$$+ [1/P_{w0}(\varepsilon_{si} Q_{si0} + \varepsilon_{di} Q_{di0})][\Sigma \varepsilon_{si} Q_{sj0} k_{ij}]/\Sigma \varepsilon_{sj} Q_{sj0} + \varepsilon_{dj} Q_{dj0})\}$$
$$\times [\Sigma \varepsilon_{sj} Q_{sj0} k_{ij}/\Sigma(\varepsilon_{sj} Q_{sj0} + \varepsilon_{dj} Q_{dj0})] \quad (9)$$

where:

CVT_{qi} is the change in the value of trade of the commodity in country 'i' as a result of research undertaken in country 'i';

ε_{si} is the own price elasticity of supply for the commodity in country 'i';

ε_{di} is the own price elasticity of demand for the commodity in country 'i'; and

k_{ij} is the spillover impact of research undertaken in country 'i' on production costs in country 'j' for the year being analysed.

As is discussed in detail in Davis et al. (1989) the ultimate cost reduction, k_{ij}, in country 'j' is best represented by:

$$k_{ij} = K_i s_{ij} \quad (10)$$

where:

K_i is the potential cost reduction in country 'i' from research undertaken in that country; and

s_{ij} is the spillover effect from research in country 'i' on production in country 'j'. Also, $0 \leq s_{ij} \leq 1$.

As they indicate values of s_{ij} apply to geographical/political boundaries (countries or regions). These need to be derived from homogeneous production environment spillovers which are more closely related to research possibilities.

3.2.3 The Change in the Value of Imported Inputs as a Result of the Impact of Research

As discussed in section 2.2.6, the possibility of imported inputs being used in the production of traded (or non-traded) commodities adds considerable complexity to model used to evaluate the impact of research on foreign exchange earnings. In the illustration used here a simple model will be adopted. It is assumed that the share of production costs spent on domestically sourced inputs is proportional to total production costs. This is the model illustrated in Figure 5. Davis and Bantilan (1990) show that it is necessary to adopt a kinked supply estimation procedure similar in nature to that used by Lindner and Jarrett (1978) to estimate the change in the value of imported inputs.

The formula used to estimate the change in the value of imported inputs is:

$$CVT_{xi} = 1/2(1 - \delta_i)Q_{si0} [(P_{i0} - M_i)(1 - Y_i^2) + 2M_i(1 - Y_i) + 2k_{ii} Y_i] \quad (11)$$

where:

CVT_{xi} is the change in the value of imported inputs used in the production of the commodity in country ‘i’;

δ_i is the domestically produced input costs as a share of total costs for country ‘i’; and

M_i is the minimum cost of producing the commodity in country ‘i’. This is used as the price axis intercept.

$$Yi = \{1 + [\varepsilon_{si} k_{ii}/P_{w0}] - [\varepsilon_{si}/P_{w0}][\Sigma \varepsilon_{sj} Q_{sj0} k_{ij}/\Sigma(\varepsilon_{sj} Q_{sj0} + \varepsilon_{dj} Q_{dj0})]\} \quad (12)$$

3.2.4 Change in the Value of Commodity Trade and Imported Input Use.

A measure of the change in the value of traded output and input use for a commodity is given by the sum of equations (9) and (11): that is,

$$CVT_i = CVT_{qi} + CVT_{xi} \quad (13)$$

where:

CVT_i is the total change in the value of traded output and input use for the commodity in country `i‘.

Inspection of the expanded version of equation (13) indicates the complexities which can be highlighted if some of the research policy objectives used in scoring models are given closer systematic interpretation. Use of equation (8) as a measure of how well research might achieve this type of objective, clearly overlooks several complex interactions which can take place. Depending on the economic and technical environment for a commodity, it is possible that an important import may, after research, have higher import values. Thus, undertaking research on this commodity may be inconsistent with achieving an import–export focused objective.

3.3 Welfare Focused Research Policy Objectives

To facilitate comparisons it is useful to express the welfare maximization and redistribution objectives used in previous studies in similar terminology to that used in this paper. Davis and Bantilan (1990) again provide details of these rearrangements. The following can be used:

$$\begin{aligned} GB_{ii} = \; & k_{ii}Q_{sio} + [Q_{dio} - Q_{sio}][\Sigma\varepsilon_{sj} Q_{sj0} k_{ij}/\Sigma(\varepsilon_{sj} Q_{sj0} + \varepsilon_{dj} Q_{dj0})] \\ & + [\varepsilon_{di} Q_{di0}/2P_{w0}]/\{[\Sigma \varepsilon_{sj} Q_{sj0} k_{ij}]^2/[\Sigma(\varepsilon_{sj} Q_{sj0} + \varepsilon_{dj} Q_{dj0})]^2\} \\ & + [\varepsilon_{si} Q_{si0}/2 P_{w0}]\{k_{ii} - [\Sigma\varepsilon_{sj} Q_{sj0} k_{ij}/\Sigma(\varepsilon_{sj} Q_{sj0} + \varepsilon_{dj} Q_{dj0})]\}^2 \end{aligned} \quad (14)$$

where:

GB_{ii} is the gross value of national welfare gains in country ‘i’ from research undertaken in country ‘i’.

The distribution of these gains to consumers within the country is given by:

$$GBCii = Q_{di0}\,[\Sigma\varepsilon_{sj}\,Q_{sj0}\,k_{ij}/\Sigma(\varepsilon_{sj}\,Q_{sj0} + \varepsilon_{d0}\,Q_{dj0})]$$

$$+ \quad [\varepsilon_{di}\,Q_{di0}\,(\Sigma\varepsilon_{sj}\,Q_{sj0}\,k_{ij})^2]/2P_{w0}\,[\Sigma(\varepsilon_{sj}\,Q_{sj0} + \varepsilon_{dj}\,Q_{dj0})]^2 \qquad (15)$$

where:

GBC_{ii} is the value of the share of gains from research in country 'i' received by consumers in country 'i'.

Finally, the equivalent measures of the distribution to producers within the country is given by:

$$GBP_{ii} = \{k_{ii} - [\Sigma\varepsilon_{sj}\,Q_{sj0}\,k_{ij}]/[\Sigma(\varepsilon_{sj}\,Q_{sj0} + \varepsilon_{dj}\,Q_{dj0})]\}Q_{si0}$$

$$+ \quad \{\varepsilon_{si}\,Q_{si0}/2P_{w0}\}\{k_{ii} - [\Sigma\varepsilon_{sj}\,Q_{sj0}\,k_{ij}]/[\Sigma(\varepsilon_{sj}\,Q_{sj0} + \varepsilon_{dj}\,Q_{dj0})]\}^2 \qquad (16)$$

where:

GBP_{ii} is the value of the share of gains from research in country 'i' received by producers in country 'i'

3.4 Comparison of Welfare Targeted and Import/Export Targeted Objectives

The formulae developed in equations (9) to (16) include several sets of complex interaction terms. These make it difficult to make simple comparisons. In this section, while an attempt is made to highlight some important differences, the full implications will be left to the perseverance of the reader.

Several important points can be readily seen. The use of the current value of trade in a commodity as a measure of the achievement of an import–export objective is simple and ignores completely the impact of the research on production. Inspection of equations (9) and (11) and comparison with equation (8) indicate that significantly different inferences could result for different commodities.

If production inputs are all domestically produced, estimating the change in the value of trade due to research requires the same set of data as the welfare oriented objectives used in research evaluation studies. However, if imported inputs are used in the production process, additional information collection will be required to estimate how research influences achievement of an import–export objective.

Table 1 has been developed to provide an indication of how the measures of the three alternative research policy objectives compare for a traded commodity. A set of simulation experiments were used to provide the assessments included in this table. The assessments of sensitivity to changes in the information or parameter should be regarded as indicative only. As inspection of the formulae reveals there are several interaction effects which mean that, under special combinations of information, most possible outcomes could apply. The main conclusion drawn from Table 1 is that as we shift across the table from a national welfare increasing objective to import–export targeted objectives the information requirements increase (although only marginally). However, what is important is the increase in the sensitivity of measure estimates to a larger set of the information and parameters. For example, the national welfare maximization is highly sensitive to four of the sixteen sets of information required, whereas the import–export targeted objective is highly sensitive to ten of them. In addition, the latter objective measure is sensitive to information which is less readily available and therefore less likely to be accurate.

Non-traded commodities will face a different set of information requirements and sensitivities.

4 A PRELIMINARY APPLICATION TO PHILIPPINE AGRICULTURE

4.1 Introduction

An empirical application of any methodology is the best way to highlight important features. Decision makers in the Philippine agricultural research system have indicated that import–export oriented objectives are important in making allocation and priority decisions. This section reports the results of a preliminary application of the measures developed to twelve agricultural commodities for the Philippines. The results presented are preliminary in that they cover a subset of the commodities to eventually be analysed and are based on a simpler version of the model than will be used in the final analysis. The final model will disaggregate the Philippines into at least thirteen regions, and the rest of the world into a mix of individual ASEAN countries and aggregated other geographical regions. In addition, more realistic modeling of research lags and strengths within the Philippines will be included, as well as different adoption possibilities. The objective of this application is to highlight the implications of the analysis and provide some preliminary results as a stimulus for interaction with research decision makers.

4.2 Information Used in the Analysis

Table 2 summarizes the data used with the formulae developed in Section 3. A single national Philippine market for each of twelve commodities is used. All other countries are aggregated as the rest of the world.

The data included in Table 2 come from two main sources:

(i) The Philippine national information was taken from: official statistical sources, for example, production and consumption; a range of individual studies, for example, supply/demand studies for elasticities and detailed farm cost surveys for minimum production costs and domestic input cost shares; and a detailed analysis of agricultural production environments to provide aggregated research spillover estimates.

(ii) The rest of the world information is taken from the ACIAR based 70 region world model data files. This information was initially described in Davis et al. (1987) but has since been (and is continually being) expanded to include more than 50 agricultural, forestry and fisheries commodities. The spillover values are aggregations of detailed estimates based on up to seventy different production environments defined independently of geographical boundaries. Davis et al. (1989) provide a summary outline of this process applied to forestry.

Table 1. A comparison of information requirements for measures of welfare and import/export targeted objectives — traded commodities

INFORMATION / PARAMETER	OBJECTIVE					
	INCREASING NATIONAL WELFARE		DISTRIBUTION OF NATIONAL WELFARE		IMPORT/EXPORT TARGETED	
	REQUIREMENT LEVEL	ESTIMATE SENSITIVITY	REQUIREMENT LEVEL	ESTIMATE SENSITIVITY	REQUIREMENT LEVEL	ESTIMATE SENSITIVITY
PRODUCTION						
National	High	High	High	High	High	High
International	High	Low	High	Medium	High	Medium
Share to Target Groups	Low	Low	High	High	Low	Low
CONSUMPTION						
National	High	High	High	High	High	High
International	High	Low	High	Medium	High	Medium
Share to Target Groups	Low	Low	High	High	Low	Low
PRICES	High	Low	High	Low	High	Low
UNIT COST REDUCTION	High	High	High	High	High	High
SUPPLY ELASTICITY						
National	High	Low	High	Medium	High	High
International	High	Low	High	High	High	High
DEMAND ELASTICITY						
National	High	Low	High	Medium	High	High
International	High	Low	High	High	High	High
RESEARCH SPILLOVER EFFECTS						
National	High	High	High	High	High	High
International	High	Medium	High	High	High	High
SHARE OF IMPORTED INPUTS IN COSTS	Low	Low	Medium	Low	High	High
MINIMUM PRODUCTION COST	Low	Nil	Low	Nil	High	Low

4.3 Analytical Results

For simplicity, results are estimated for a single time period rather than discounted over the full period from research inception to technology replacement. Since there are often significant adaptive research lags before international spillovers are transformed into cost reductions, two sets of analysis were undertaken. The first, summarized in Table 3, assumes all spillovers have taken place. Therefore, maximum expected world price effects will have occurred. The second, given in Table 4, represents the time period when only domestic production is affected by research. If the Philippines supplies a significant share of world production and trade, as for example is the case with coconuts, then some world price effects will occur, if not, a small country traded good situation will apply and commodity prices will change little due to the impact of research.

Comparison of Tables 3 and 4 illustrates the importance of spillovers to the impact estimates for each type of objective. In general, unless trade is a major share of total production, the national benefits maximization objective estimates are not greatly affected by the time lag. Since the gross value of trade is not influenced by research impacts this measure remains unchanged in each situation.

The considerable difference in price effects between the two situations means significant changes in the measure estimates for the other two objectives. Consumer and producers shares change with price, as expected, producer shares increasing substantially with reduced world prices effects. Measures of the change in the value of trade due to research are also sensitive to the price impact resulting from between-country spillovers. As expected, some commodities (e.g. bananas) recording net increases in the value of imports or decreases in the value of exports have this situation reversed. This results from limited domestic consumption increases because of only small, if any, price decreases.

The type of results reported in Tables 3 and 4 can be used in many ways to support research resource allocation decision making. This paper focuses on one of these possibilities – their use to assist research priority setting.

4.4 A Comparison of Commodity Research Priorities for Alternative Research Objectives

Once quantification of measures for each possible objective has been completed there are no well developed methods for transforming them into research priorities. The approach used by, for example, Davis and Ryan (1989) is adopted here. Briefly, this involves using the information in Table 3 (or 4) to calculate research relativities. These research relativities are then used to allocate commodities into high, medium and low groupings according to how well the measures indicate they contribute to satisfying the particular research policy objective.

Table 5 provides these priority groupings for the model which includes international research spillovers (that is, using Table 3)[2]. Two research policy objectives are illustrated. Priorities for

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[2] Similar tables were developed prior to spillover estimates. Since results were not substantially different they are not presented here.

Table 2. Basic data used in the calculation of export/import objective measures and comparison with national benefit objectives

Philippines	Rice	Maize	Coconuts	Milk	Soybeans	Banana	Sweet Potato	Cassava	Sugar	Coffee	Cocoa	Cotton
Price	327	148	80	295	244	275	127	69	315	3120	1965	140
Production	5303	3486.5	11007	33.3	7.7	3813.9	709	1440	3068	128	5.2	5.8
Consumption	5230.7	3684.3	4310	751.9	25.5	3069.2	709	1440	1316	62	5	24.8
Elasticity of Supply	0.33	0.17	0.6	0.2	0.32	0.4	0.05	0.5	0.68	1.05	0.21	0.8
Elasticity of Demand	0.42	0.4	0.5	1.08	0.7	0.77	0.25	0.2	0.24	0.3	0.5	0.29
Own Spillover	0.583	0.612	0.654	0.315	0.762	0.599	0.618	0.62	0.604	0.528	0.874	0.732
Unit Cost Reduction	16.4	5.7	4	14.8	12.2	13.8	4	2.6	15.8	156	97.5	7
Domestic Cost Share	0.8	0.68	0.95	0.8	0.74	0.98	1	0.97	0.82	0.63	0.19	0.61
Minimum Production Cost	124	110	20	150	216	34	37	15.71	120	442.43	1332.08	151.54
Rest Of World												
Price	327	148	80	295	244	275	127	69	315	3120	1965	140
Production	294575.9	426886.8	36877	504440	90131	58307.6	139733	130441	98498	5606	1800	16573
Consumption	294648.2	426689	43574	503721.4	90113.2	59052.3	139733	130441	100250	5672	1800.2	16554
Elasticity of Supply	0.3	0.4	0.66	0.84	0.4	0.4	0.5	0.5	0.5	0.73	0.54	1.01
Elasticity of Demand	0.4	0.5	0.9	0.8	0.55	0.4	0.7	0.79	0.51	0.2	0.5	0.9
Spillover	0.361	0.251	0.641	0.188	0.136	0.45	0.324	0.524	0.157	0.342	0.825	0.229

Table 3. Estimates of the annual impact of research for each objective — model with international spillovers

COMMODITY	National Benefits	Consumer Benefits	Producer Benefits	Gross Value	Change in Trade	Change in Commodity	Change in Input
Rice	50670	13459	37211	23642	14115	6355	7760
Maize	12307	2353	9954	29274	4236	872	3364
Coconuts	21526	4765	16761	535760	1095	141	954
Milk	1182	1074	108	211987	-79	-106	27
Soybeans	84	18	67	4343	34	21	13
Banana	29335	9548	19788	204793	-1270	-1747	477
Sweet Potato	1753	292	1461	0	0	0	0
Cassava	2325	1661	664	0	60	0	60
Sugar	27078	1820	25258	551880	16376	14094	2282
Coffee	7768	2649	5119	205920	3636	1669	1966
Cocoa	436	210	227	393	258	-64	322
Cotton	46	21	25	2660	34	30	4

Table 4. Estimates of the annual impact of research for each objective — model without international spillovers

COMMODITY	National Benefits	Consumer Benefits	Producer Benefits	Gross Value	Change in Trade	Change in Commodity	Change in Input
Rice	50938	416	50521	23642	23317	16408	6909
Maize	12188	20	12168	29274	5304	2058	3247
Coconuts	27428	1030	26398	535760	14214	13539	675
Milk	156	0	155	211987	56	31	25
Soybeans	72	0	72	4343	36	23	13
Banana	31520	762	30759	204793	11843	11451	392
Sweet Potato	1753	292	1461	0	0	0	0
Cassava	2325	1661	664	0	60	0	60
Sugar	29229	255	28974	551880	20936	19093	1844
Coffee	10546	128	10419	205920	10579	10613	-34
Cocoa	445	0	445	393	380	93	287
Cotton	30	0	30	2660	26	24	3

the import–export focused objective are developed using the two alternative measures discussed and developed earlier in the paper. The first is based on equation (13) and measures the change in the value of traded output and inputs due to the impact of research. The second is the measure commonly used in scoring models; that is, the gross value of current trade.

Table 5. Commodity research priority groupings for different objectives: Philippine agriculture (incorporating international research spillovers)

Priority grouping	Objective		
	National benefits maximization	Import–Export Targeted	
		Change in value of trade	Gross value of current trade
High	Rice Banana Sugar Coconuts Maize Coffee	Sugar Rice Maize Coffee	Sugar Coconuts Milk Coffee Banana
Medium	Cassava Sweet Potato Milk	Coconut Cocoa	Maize Rice
Low	Cocoa Soybeans Cotton	Cassava Cotton Soybeans Sweet Potato Milk Banana	Soybeans Cotton Cocoa Cassava Sweet Potato

The results indicate that, even for this small subset of important commodities, significant differences exist in the priority groupings. For each objective and even alternative measures for the same objective commodities are in different groupings.

Tabular comparisons of this type of information often do not clearly demonstrate these differences. Davis and Ryan (1989) suggest a box-diagram representation as an effective means of presenting such comparisons to decision makers. Figure 8 provides such a representation for the two alternative measures of an import–export focused research policy objective. Here the change in the value of trade priorities is represented on the vertical scale and gross value of current trade on the horizontal scale. High to low are listed from top to bottom for the former and from right to left for the latter measure.

Commodities entered in the left to right upward diagonal are those which are given the same priority using either measure. For example, sugar is high for both the change in trade values and the gross value of current trade. Similarly, soybeans are low priority for both. On the other hand, milk is low priority for the change in trade but high for the gross value measure. The more commodities in off-diagonal boxes, the less consistent are research priorities determined by either measure.

In Figure 8 it is seen that only half of the commodities are given similar priorities using alternative measures. On the basis of these results it seems reasonable to conclude that care is required in choosing the appropriate measure to use for a particular research policy objective. Inappropriate priority information may be generated if an inappropriate measure is chosen.

The same type of presentation can also be used to compare priorities developed for different research policy objectives. Figure 9 includes the national welfare maximizing objective on the vertical axis and the change in value of trade measure of the import–export objective on the horizontal axis.

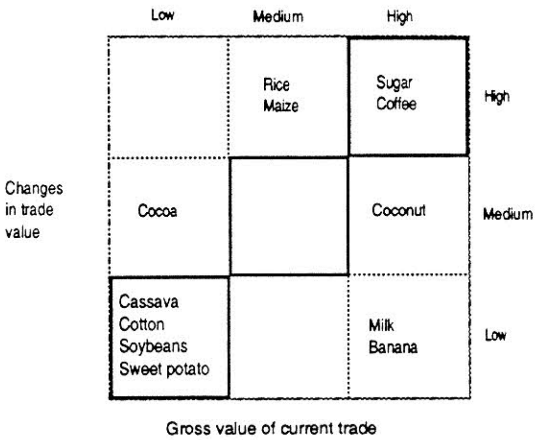

Fig. 8. A comparison of alternative measures of import–export focused objectives

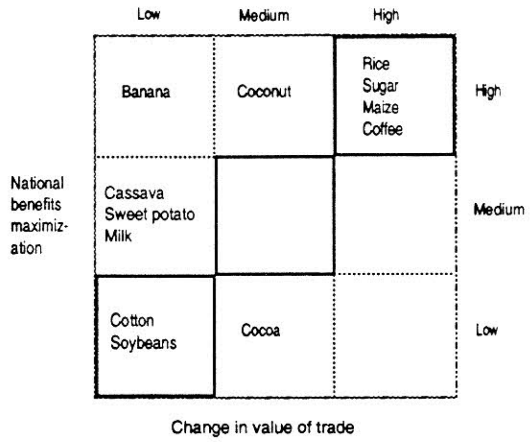

Fig. 9. A comparison of national welfare and import–export targeted research policy objectives

In this comparison, half of the twelve commodities are allocated to matching research priority groupings. The remaining set indicate conflicts in priorities between objectives. Unless commodities in the diagonal boxes are chosen for research emphasis, conflicts in achieving research policy objectives will occur. The information generated by the analysis can provide indications of the opportunity costs likely to be involved. If multiple objectives are still considered to be important, this information can be used by decision makers in adjudicating on conflicting commodities. If necessary, weighting procedures can be developed to develop compromise priority groupings.

5 CONCLUSIONS

This paper has attempted to develop a more systematic discussion of a commonly expressed agricultural research policy objective. The objective is usually stated as import replacement and/or export enhancement. Existing literature has not discussed this objective in any detail and has not attempted to develop quantitative measures for use in assessing whether research options are likely to achieve this type of objective.

Several important conclusions can be drawn from the discussion. First, it has been shown that a clearer specification of these types of objectives is required. This specification needs to include assessments of such factors as whether only trade in the final commodity is relevant or whether traded inputs should also be included? Also, should any consideration be given to the domestic resources used in the production of the commodity? A research strategy which ignores the opportunity cost of domestically produced inputs or resources may not provide the highest level of national welfare.

A set of alternative quantitative measures was developed for assessing how well research on a particular commodity is likely to contribute to this import–export focused objective. The first was the measure commonly used by 'scoring model' style priority assessments. The second was derived from the interpretation of this objective developed in this paper.

A preliminary empirical application to Philippine agriculture reveals the likelihood of significant conflicts in the research priority groupings of commodities between measures. It is concluded that, if indeed it can be shown that such an objective is appropriate for research policy, then the change in value of trade due to research impacts is the preferred measure.

A comparison between an import–export objective and a national welfare gains maximization objective indicated that conflicts in resultant commodity research priority groupings are likely to exist. Care is required in adopting these objectives to ensure opportunity costs are in the social interest.

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