An Examination of Nearly Green Programs: Case Studies for Canada, the United States and the European Union

Economic & Policy Analysis Directorate
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Table of Contents

Acronyms

AAFC	Agriculture and Agri-Food Canada
AMS	Aggregate Measures of Support
CAP	Common Agricultural Policy
CRP	Conservation Reserve Program
EU	European Union
FAIR	Federal Agriculture Improvement and Reform
NES	Net Eligible Sales
NISA	Net Income Stabilization Account
PFC	Production Flexibility Contract
WTO	World Trade Organization

Preface

This report is part of the Trade Research Series that Agriculture and Agri-Food Canada (AAFC) is undertaking to support discussions in connection with multilateral and bilateral trade negotiations. The purpose of the series is to create an inventory of research that will make it easier for stakeholders to identify concerns, issues and opportunities associated with such discussions. The research is for the most part directed to areas in which little or no information has been circulated rather than to areas in which a broad base of literature already exists. More information on the Trade Research Series is available on the AAFC website at *www.agr.ca/policy/epad*, or by contacting Brian Paddock, Director of the Policy Analysis Division, Policy Branch (email: *Paddobr.em.agr.ca*, phone: (613) 759-7439).

This report is the second of two reports undertaken by the Policy Branch of AAFC concerning World Trade Organization (WTO) "green box" criteria and production neutrality. The first report introduced the subject by providing a non-technical discussion on whether green box criteria is sufficient to ensure the production neutrality of direct payment programs. This second report is more technical in nature, and examines direct payment programs in Canada, the United States (U.S.) and the European Union (EU) against the standard of production neutrality.

Preliminary results from these reports were presented at the International Agricultural Trade Research Consortium Annual Meeting in St. Petersburg, Florida, December 1998.

Abstract

This paper addresses the production neutrality of U.S. Production Flexibility Contract (PFC) payments under the Federal Agriculture Improvement and Reform (FAIR) Act, Canada's Net Income Stabilization Account (NISA), and the EU system of compensatory payments for arable crops. The U.S. PFC payments are viewed as largely neutral because the recipients cannot affect the size of the payouts and therefore only have incentives to respond to market signals. However, the neutrality of the program can be violated because of wealth effects, because the payment relaxes a production constraint (i.e., a debt constraint) or because the payment induces investment. It is difficult to predict the production effects of NISA because of the complexity of the program. Although the matching government contributions may create an incentive to increase net eligible sales, the program also increases the opportunity cost of productive assets which has a dampening effect on production. The production neutrality of NISA is probably enhanced by the program being generally available across a range of productive activities. The EU's program of arable compensation payments affects cropping patterns but does not induce yield growth.

Introduction

The negotiators of the Uruguay Round recognized the potential for domestic programs to adversely affect trade. They also recognized that not all forms of domestic support are trade distorting and they allowed that measures deemed to have "no, or at most minimal, trade distorting effects or effects on production" to be exempt from domestic support reduction commitments.

This is the second of two papers which examine the potential of programs that are classified as "green" under Annex 2 of the WTO Agreement on Agriculture, to distort trade. The first paper examines whether the criteria that define which domestic programs are exempt from domestic support reduction commitments are sufficient to ensure production neutrality.[1] In particular, it examines the criteria for direct payments to producers as: decoupled income support, income insurance and safety net programs, structural adjustment assistance, regional assistance and environmental aids. It also makes some recommendations for reform of the green box criteria.

This paper assesses specific government programs against the standard of production neutrality. It does not look at the legality, according to Annex 2 criteria, of whether the program should or should not be in the green box.

The programs examined in this paper were chosen because they represent major policy tools in three major agricultural exporters: the European Union, Canada and the United States. Only one of the three programs examined, the U.S. FAIR Act production flexibility contract (PFC) payments program is currently notified under Annex 2. The European Union compensatory payments, which arose from the reform of the Common Agricultural Policy (CAP), are notified under Article 6:5 (blue box) of the Agreement on Agriculture where direct payments under production limiting programs are not subject to reduction commitments for domestic support. The third program considered is Canada's Net Income Stabilization Account (NISA)

1. Since the green box excludes all market price support, consumption distortions should be minimal. As a result, production neutrality should be equivalent to trade neutrality.

program which is currently notified as non-product-specific Aggregate Measures of Support (AMS). While neither the Canadian nor the EU programs are notified as green, it is relevant to consider them in the context of Annex 2.

The first chapter of this paper examines the U.S. program. Chapter 2 examines the Canadian program whereas Chapter 3 examines the European Union program. Chapter 4 provides a comparison of the different programs. Chapter 5 provides a program classification according to production neutrality and discusses prerequisites for program placement in that classification.

Chapter 1: Decoupled Payments: U.S. FAIR Act Production Flexibility Contracts

The FAIR Act of 1996 authorizes annual PFC payments which participating producers may receive independent of farm prices and production. To receive payments, farmers who participated in the wheat, feed grains, rice, and upland cotton programs in any one of the years 1991 through to 1995 may enter into seven-year production flexibility contracts (1996-2002). They must comply with conservation requirements and keep contract acres in agricultural or related uses (production is not required). An eligible farm's payment is based on its payment quantity for each contract crop multiplied by the respective annual payment rate determined for that crop. The payment quantity for a given contract commodity is equal to 85 percent of the farm's contract acreage times its fixed program yield. A per-unit payment rate for each contract commodity is determined annually by dividing the total annual contract payment level for that commodity, by the total of all eligible farms' payment quantities. Annual payment quantities may be affected by producers exiting the program, withdrawing some acreage, enrolling contract acreage into the Conservation Reserve Program (CRP), and by previous CRP acreage becoming eligible for payment. The sum of such payments across contract commodities for an individual farm would be its annual payment, subject to payment limits.

The total PFC payment levels for each fiscal year (October 1–September 30) are fixed at: \$5.186 billion in 1996, \$6.288 billion in 1997, \$5.660 billion in 1998, \$5.603 billion in 1999, \$5.130 billion in 2000, \$4.130 billion in 2001, and \$4.008 billion in 2002. The share of total annual payments was fixed for each commodity for the seven-year period based upon February 1995 projections of deficiency payments.

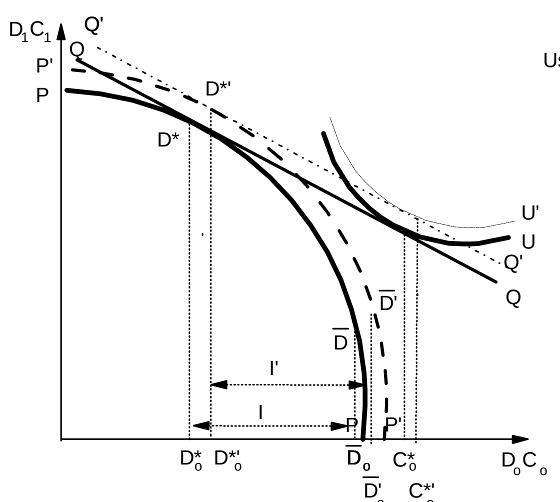
The idea of decoupled support can be traced to a simple idea in economics, which is the lump sum transfer. A lump sum transfer is one where the recipient cannot affect the size of the transfer (tax) by changing his behaviour in any manner. Such transfers are understood not to distort the economy's resource allocation because they do not alter an agent's incentives. Agriculture support programs have been developed which try to approximate a lump sum transfer by tying support to some historically fixed variable, such as past production, so that the producer cannot affect the size of the pay-out. These transfers are often compensation payments and the expectation is that the size of the payment is related to the income loss incurred. The rationale is that since direct payments are based on a past, fixed base period, producers cannot affect the size of the payment through current behaviour, and their current production decisions will only be based on market considerations.

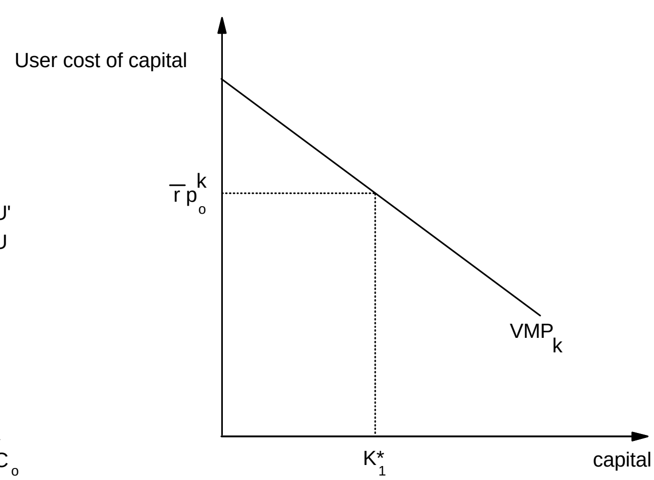
PFC payments under the FAIR Act appear to meet the requirements of a decoupled program. The neutrality of these payments depends on the subsidy not affecting decisions at the margin. However, there are instances where such payments may not be neutral, that is there are situations where the direct payment indirectly affects the decision at the margin. In those instances where the producer faces a constrained optimization problem, the market will dictate that he behave differently with and without the constraint. A direct payment may reduce the constraints limiting a farmer's production potential and as a consequence production may increase. The companion paper introduced three examples of a direct payment relaxing a constraint and thereby increasing the optimal level of production:

- increasing returns to scale with restrictions on profit maximization;
- behavioural theories of the firm (satisficing behaviour), and;
- debt constraints.

This paper will examine the implications of the debt constraint in more detail using a model developed by Phimister (1995). With this approach, Phimister demonstrated that direct decoupled payments are not production neutral in a household production/consumption model where debt is a constraining factor. Producer decisions are based on a greater range of considerations than simply maximizing profits, and include household preferences and farm financial structure. In the absence of a debt constraint the farmer/householder optimizes in a recursive fashion where he maximizes profits first determining output and income, and then maximizes utility to allocate his lifetime consumption given a lifetime budget constraint. Compensation through a lump sum payment does not affect his profit maximizing decision. This is illustrated in figure 1 (this figure is adapted from Phimister using diagrams explained in Gravel and Rees [1981] p.p. 406-415).

Figure 1





The left-hand diagram in figure 1 shows a two-period model of inter-temporal consumption and investment decisions. The bowed curve PP is the feasible combination of cash flows[1] that the farmer can receive by varying his investment decision. The point $\overline{D}$ is assumed to be the cash flow stream where the producer does not invest or dis-invest. The line QQ is a wealth line where higher lines will present the farmer with better consumption possibilities and increase household utility (represented by an indifference curve U). The farm's optimal investment decision (or choice of K_1) is that which maximizes the farmer's wealth (i.e., the highest attainable wealth line along PP) at point D*. This is achieved by choosing a second period capital stock K_1* and investing $I = p^k(K_1 - K_0)$. The right hand panel shows the determination of the optimal capital stock for the next period. The optimal level capital is determined by equating the value of the marginal product of capital with the user cost of capital (which depends on the price of capital p^k and the household's internal discount rate $\bar{r}$). The level of consumption in each period is determined by the ability to save or borrow. The household can increase first period consumption and move down and to the right along the wealth line QQ by borrowing. The rate at which the household can borrow is determined by the interest rate. The slope of QQ is given by -(1+r). Where the indifference curve U is tangent to QQ determines the level of consumption in the first period, C^*_0, and household has to pay back $(1+r)(C^*_0-D^*_0)$ in the next period. The slope of the indifference curve is $(1+\bar{r})$ where $\bar{r}$ is the household's rate of time preference (or internal rate of interest). In equilibrium the household's internal rate of interest $\bar{r}$[2] equals the market rate of interest, r.

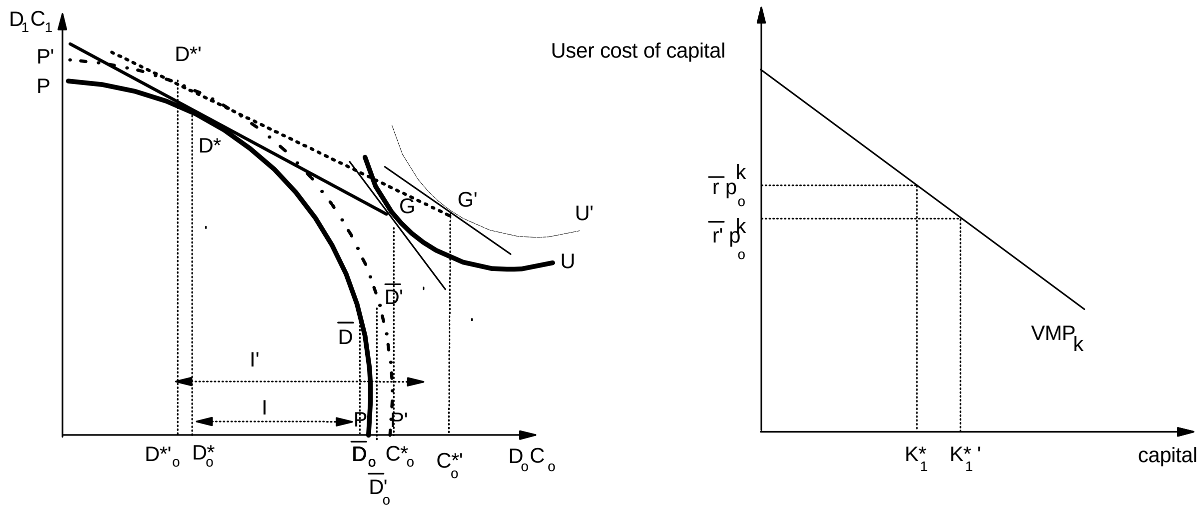
The household's internal discount rate plays a pivotal role in coordinating consumption and production. It determines the marginal rate of substitution in household consumption across time while also affecting the user cost of capital.

In the situation with no debt constraint a lump sum payment shifts the farm's feasible combination of cash flows to P'P'. The new wealth line Q'Q' is tangent to P'P' and a higher indifference curve U'. Since the household's internal rate of interest $\bar{r}$ continues to equal the market rate of interest, r, the user cost of capital remains the same and the optimal choice of capital for the next period k_1 also remains the same. The model can be solved recursively. The profit maximizing capital stock remains unchanged by the direct payment, but the household's consumption and utility increase as a result of the lump sum payment.

Figure 2 illustrates the impact of a debt constraint. With a debt constraint in place, the household can only borrow D*G such that its internal discount rate $\bar{r}$ does not equal the market rate of interest r (i.e., the indifference curve is not tangent to the wealth line D*G). The introduction of direct payment shifts the farm's feasible combination of cash flows to P'P'. The direct payment relaxes the debt constraint to D*'G' and as a result the household's internal discount rate $\bar{r}'$ declines as the tangent to the indifference curve U' becomes flatter (in absolute terms). As the household's internal discount rate declines, optimal level of capital in the next period k_1' increases, and so does production.

1. The cash flow for the two periods is:
   $D_0 = pf(K_0) - p_k(K_1 - K_0) - I$
   $D_1 = pf(K_1)$
2. $\bar{r} = U_0/U_1 - 1$ where U_i is marginal utility with respect to consumption in period i.

Figure 2



The debt constraint increases the opportunity cost (i.e., $\bar{r}'$ increases) of the current acquisition of capital at the expense of maximizing the utility of consumption over time. Relaxing the debt constraint decreases this opportunity cost and allows more funds to be allocated to future production. The payment which was neutral in the non-debt constrained case now increases future production.

Roberts (1997) argues that given a farmer's specialized skills and knowledge in farming, and the absence of perfect capital and information markets, significant amounts of decoupled payments are likely to be invested in the farm. So it can be argued a wealth effect alone can induce production. In a more formal sense it can be shown that, in a stochastic environment with a risk averse producer, a decoupled payment will affect production through a wealth effect (see for example Hennessy [1998] or Sandmo [1971]). If the payments are large and stable relative to market earnings, then aggregate income will be higher and more stable than if the market is the only source. For risk averse producers, a reduction in risk shifts the supply curve to the right. The reduction in risk also lowers the cost of borrowing, and this in turn may lead to more agricultural investment.

As the value of the direct payments are increased, they become capitalized into land values. The increase in land values tends to hold land in agricultural production. As the PFC payments decline, land values should decline over the longer run. The fact that not all farmers are land owners, and that not all land owners are farmers, adds to the difficulty of predicting whether direct payments will inhibit or promote adjustment of resources out of agriculture. Furthermore, the PFC payments may also become capitalized in other quasi-fixed farm-owned assets, which should also restrict the movement of productive resources out of agriculture.

Summary for Decoupled Payments

There are a number of circumstances where the neutrality of decoupled payments can be violated. For a risk averse producer, the wealth effect of decoupled payments is sufficient to change production. If the decoupled payment is structured appropriately, it can lead to a reduction in income risk which in turn leads to increased production. Also, a decoupled payment will not be neutral where the payment is sufficient to relax a constraint facing an optimizing producer. For these reasons, it is not desirable to provide open-ended support even through decoupled payments.

Chapter 2: Consumption Smoothing Programs: NISA

NISA is a voluntary farm income safety net scheme where Canadian farmers can set aside money in individual accounts which is then matched by federal and provincial government treasuries. Producers can deposit up to 3 percent of their eligible net sales[1] and receive a matching contribution (2 percent from the federal government and 1 percent from the provincial government). Producers also receive a 3 percent interest bonus, over and above competitive rates, on their contributions. The maximum net sales for the qualifying matching government contribution is set at $250,000 per farm. A producer also has the option to contribute an additional 20 percent of net eligible sales (NES) into their account. These additional deposits are not matched by governments, but they earn the 3 percent interest bonus over and above regular interest rates. Farmers can make withdrawals from the account when their income falls below their five-year average returns after costs, or when their taxable income falls below a fixed level. The program is designed to give farmers a special rainy day savings account, which encourages savings during good years for use in poor years.

Canada has not notified NISA as complying with the WTO Agreement on Agriculture Annex 2 criteria to be exempt from domestic support reduction commitments. Yet many consider the program to be production neutral. Can the program be considered production neutral, or at best, minimally distorting? When addressing the effect of NISA on production decisions, it is necessary to ask three questions:

1. Do producers have an incentive to increase their NES in order to qualify for larger government contributions?
2. Do producers have an incentive to trigger pay-outs?
3. Is the program neutral because it is not specific to one particular enterprise?

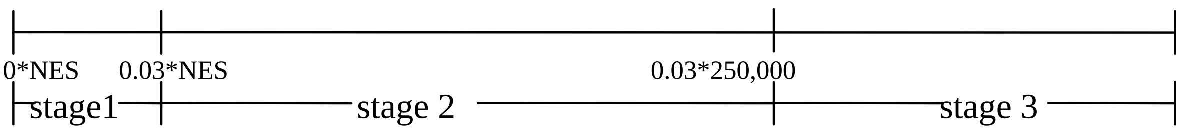
Each of these questions will be considered in turn.

1. Eligible net sales are calculated by taking gross sales of qualifying commodities less the purchase of qualifying commodities.

Do producers have an incentive to increase sales to get larger government contributions?

The nature of the program design of NISA requires that its effect on production decisions be examined in stages. Figure 3 describes these stages.

Figure 3: Scale of Government Contributions to NISA Account



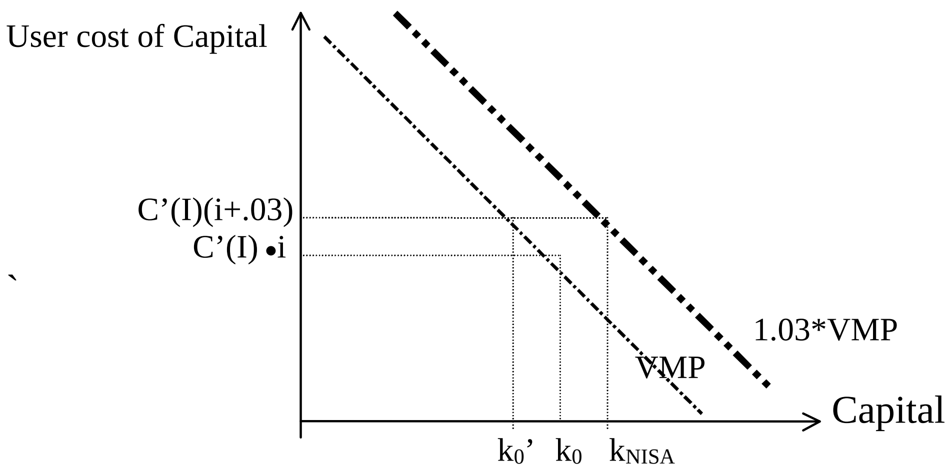
In the first stage, for contributions below 3 percent of NES, producers can increase their contributions (as percentage of NES) without increasing NES and still get more matching government payments. In the second stage at contributions above 3 percent of NES, the producer can continue to contribute up to another 20 percent of NES and receive a 3 percent interest bonus above regular interest rates, but no additional government contribution above 3 percent of NES is provided. At this second stage, the only way that the producer can earn additional government contributions is to increase NES. In stage 3, at $250,000 in NES the government contribution is at a maximum—there is nothing that the producer can do to increase the size of the government contribution and the payment can be considered essentially decoupled.[2] Stage 2 is the only zone in which there is a possible incentive to increase production in order to get a larger matching government contribution. Statistics for NISA in 1995 indicate that, across all eligible commodities, the participation rate was 84 percent. The share of NISA participants with NES of $250,000 and over was 54.5 percent. A further nine percent of the participants made contributions of less than 3 percent of NES. This suggests that roughly 30 percent of NES may fall into stage 2.

Appendix A examines the decision by a farmer in stage 2 of whether to increase production in order to increase government NISA contributions. This analysis examines the farmer's decision within a dynamic household production model. The model looks at the problem as a savings-consumption decision and examines the portfolio allocation between real assets and savings. To facilitate the analysis, a very simple model is employed where a farmer is assumed to produce one output with one input capital (or real assets). The farmer has to make a decision whether to invest in capital equipment, to increase output in future periods, or to save the money. NISA is assumed to be the farmer's only savings instrument. Increased investment comes with the benefit of future increased government NISA contributions but also comes at an opportunity cost of current reduced savings. The 3 percent interest rate bonus of the NISA program increases the opportunity cost of forgoing current savings. The decision to expand savings comes at the expense of acquisition of real assets and the potential that future production may decline.

2. Farmers may be able to increase contributions by splitting the farming operation among family members because of the $250,000 cap. In this way, the effective level of decoupling actually may be $500,000 or higher. This consideration is not taken into account in this analysis.

The model's decision rule for additional real assets, in a steady state, is that the marginal value of additional capital has to be greater than the user cost of acquiring additional capital (user cost of capital). NISA has two opposing effects on this decision rule: the matching contribution adds 3 percent to the value of the marginal product of capital; however, the 3 percent interest rate bonus increases the opportunity cost of purchasing capital equipment versus holding the funds in the bank. This is illustrated in Figure 4.

Figure 4



In figure 4 C'(I)·i is the user cost of capital (which can be thought of as the price of capital times the market rate of interest). In the absence of NISA, the optimal capital stock would be determined where the user cost of capital, C'(I)·i, equals the value of the marginal product of capital, VMP. The introduction of NISA increases the opportunity cost of capital by the interest rate bonus of 3 percent, so that the optimal capital stock declines to k_0'. The matching government contribution, at 3 percent of NES, increases the profitability of investment in the capital good so that the VMP curve shifts to the right by 1.03*VMP. This effect increases the amount of desired capital and enhances production. Figure 4 is drawn so that the shift in the VMP exceeds the increase in the opportunity cost of capital. This may not always be the case and, if the increase in the opportunity cost of capital exceeds the increase in the VMP as a result of matching government contributions, then capital may decline and so would future production.

Whether or not NISA increases production comes down to whether 0.03 times the value of the marginal product of capital exceeds the size of the NISA interest rate bonus.[3] Production may decline when the interest rate bonus is greater than 0.03 times the value of the marginal product of capital.[4] Given the relatively small share of production occurring in stage 2, the off-setting effects as described above, and the multifaceted nature of the program which

3. It should be noted that NISA raises the opportunity cost of capital for all three stages (at the margin for stages 1 and 2, and infra-marginally for stage 3). The opportunity cost is the highest at stage 1, because of the foregone matching contribution.
4. The possibility that producers could purchase commodities to resell and thereby increase government contributions has been anticipated in the program design so that the determination of NES is calculated as gross sales less the purchases of qualifying commodities.

blurs the incentives to increase NES, the production enhancing effects of NISA should be minimal. Certainly, the production effect of NISA relative to that of other safety net programs, is much smaller.

Do producers have an incentive to trigger pay-outs?

The second issue is whether producers can change their behaviour to trigger a pay-out. Since producers individually have no influence over price, the only determinants of net income that they can affect are yields and the use and timing of the purchase of inputs.[5] Producers will have access to all the funds in the NISA account at some point in their lifetime… most likely at retirement. The question of when the monies should be withdrawn is determined by the participant's time preference for consumption. If the producer/consumer values current consumption much more than future consumption then there will be an incentive to trigger early withdrawals.

Whether households/producers choose a pattern of consumption that rises, stays constant, or falls over time will depend on the following relationship:

$$\dot{X}/X = \sigma \bullet [(i + s) - \rho]$$

The left-hand term in this expression is the proportionate change in household consumption over time. The term σ is the elasticity of inter-temporal substitution between consumption, at different time periods, which measures the willingness of households to accept deviations for a uniform pattern of consumption over time. The term $[(i+s)-\rho]$ is the difference between the augmented market rate of interest and the household's rate of time preference (i.e., household's subjective rate of interest). For the consumer to value current consumption much more than future consumption, the left-hand term has to be negative. Since σ is positive, in order for $[(i+s)-\rho]$ to be negative then $\rho > (i+s)$. The 3 percent interest rate subsidy decreases the possibility that the producer/consumers rate of time preference is greater than the NISA bonus augmented interest rate. The more likely event is that producers will treat NISA as an RRSP and leave monies in the account even if the funds have been triggered to be eligible for withdrawal. Indeed the empirical evidence on NISA withdrawals supports this claim because participants are not withdrawing funds when they are triggered.

Does General Availability make NISA more neutral?

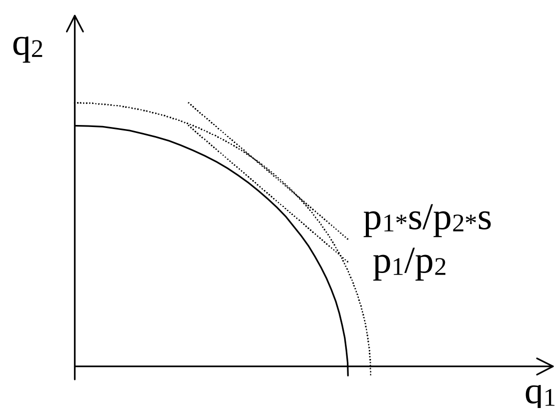
We have seen that in order for NISA to induce production, the farmer must already be making the maximum contribution eligible for government matching (i.e., he must be in stage 2). Furthermore, the incremental increase in the value of the marginal product of real assets (capital) must be greater than the addition to the opportunity cost of capital as a result of the NISA program. Given these considerations, there is another aspect of the program which influences resource allocation. NISA is a whole farm program (with the exception of supply managed products)[6]. This has implications in both economic terms and in trade law.

5. It should be noted, that NISA could motivate the producer to reduce production in order to trigger a pay-out.
6. However, to the extent that supply managed farmers participate in NISA through their other operations, the presence of a production quota could mitigate any cross commodity effects from NISA into the supply managed sector.

Appendix B deals with the multi-commodity aspects of NISA. In this appendix, NISA is treated as a subsidy which is x% of total revenues. This subsidy is net of the effects considered above so that x% is the true subsidy element of the NISA program. The effect of this net subsidy element on production when more than one good is involved depends on the firm's cost structure. Consider the two-product case. If the two products are non-joint (that is the production of one product does not affect the production of other products) then the effect of the subsidy will be the same as in the single good case. The subsidy will increase the production of both goods. With joint production the impact of the subsidy will depend on the cross effects of output changes on the firm's cost function. The cost function can exhibit complementaries, substitutability or non-jointness. An example of cost complementaries would be a situation where NISA allows a crop producer to reallocate his portfolio, invest in a larger tractor or better equipment to lower his costs and as a result produce more of all crops. Cost complementaries can also be thought of as economies of scope. With cost complementaries the effect of the subsidy will unambiguously increase the output of all goods. With cost substitutability the effect of the subsidy can be partially (or fully) cancelled out across commodities. With perfect substitutability between outputs (for example the linear land constraint imposed in Chapter 3) the effect of equal subsidies to each product will cancel each other out.

Figure 5 provides some intuition about the effect of cost complementaries. The figure represents the farmer's transformation function (i.e., production possibility frontier) which shows the trade-off in production between outputs q_1 and q_2. The effect of cost complementaries (economies of scope) can be thought of as shifting the farm's transformation function outwards (to the dashed line). When a common subsidy, s, is applied to both products relative prices, p1/p2, remained unchanged (since both the denominator and the numerator are multiplied by s), but the farmer achieves a higher level of output for both products as a result of the subsidy, s.

Figure 5



Can Canadian agriculture be characterized with economies of scope? There is relatively little empirical evidence on which to base a conclusion. Those farms, which consist entirely of crop enterprises, are most likely to exhibit cost substitutability so that the effects of an equal subsidy tend to cancel out across crops. A mixture of livestock and crop production raises the possibility of scope economies. Kunimoto (1983) rejected cost complementaries between field crops and livestock for Canadian agriculture. However, this does not rule out potential economies of scope for small mixed farming operations. Chavas and Aliber (1993) examined the production technology of Wisconsin farmers and found that most farms exhibit substantial economies of scope, but that such economies tend to decline sharply with the size of the enterprises. If economies of scope are limited to relatively small-scale enterprises, the potential for a distortion in aggregate production is limited. Therefore, general availability should make NISA more production neutral.

Summary for NISA

NISA is conceptually a difficult program to model because of the many facets of the program. The complexity of the program also likely limits the potential that producers will freely exploit the program to maximize government contributions. Although the matching government contributions create an incentive to take advantage of the program for government payments, the program also increases the opportunity cost of productive assets which has a dampening effect on production. The production neutrality of NISA may be enhanced because the program is generally available across productive activities. However, this neutrality may be compromised where economies of scope in joint production occur.

Chapter 3: Production Limiting Programs: EU Compensatory Payments

In its 1995/96 (marketing year) notification for domestic support, the European Union reported 20.8 billion ECU of production-limiting direct payments which are exempt from reduction commitments under the "blue box" (Article 6:5) of the Agreement on Agriculture[1]. The payments consist of 15.6 billion in arable crops compensatory payments and 5.2 billion in headage payments for livestock. This paper will only consider the potential impact on production of the arable crop payments.

The 1992 reform of the CAP represented a shift in emphasis from market price support to direct support of the producer. The most significant component of CAP reform concerns the grains and oilseeds sector. The target price level was reduced by almost 30 percent. Individual producers were compensated through direct compensatory payments, which equal the difference between the 'reference price for aid'[2] and the reduced price. The payment is conditional upon a set aside.[3] The set-aside condition only applies for commercial producers. Producers who grow less than 92 tonnes (which for a Community average yield of 4.6 tonnes/ha equals approximately 20 hectare holdings) are exempt from the set aside and receive direct compensatory payments. Crops which are grown for industrial use are also exempt from the set aside restrictions.

Per hectare compensation payments are based on a fixed ECU value times a fixed historic regional yield. The fixed per hectare payment effectively decouples the payment from yield.[4] A producer cannot affect the size of his payment by changing yields and therefore has no incentive to expand yields beyond what market conditions would dictate. However, the choice of crop mix is still influenced by the size of the payment since payments for cereals,

1. Special temporary exemption category which requires that the amount of payments be based on fixed area and fixed yields, or a fixed number of livestock. The payment cannot exceed 85 percent of base levels.
2. This is the July 1991 buying-in price of 155 ECU which is 94 percent of the intervention price. By 1996, the target price was reduced to 110 ECU with a compensation rate of 45 ECU.
3. The size of the set-aside has varied over time ranging from 15% for rotational land in 1993/94 and 1994/95, to 5% in 1997/98.
4. This argument has been made by a number of authors including Sarris (1992 p.43), Josling (1994, p516), Guyomard et. al. (1996 p. 402).

oilseeds, and protein crops differ. The per hectare payment for cereals is 54.34 ECU/t times average historic yield; the protein crop payment is 78.49/t ECU times average historic yield; and the oilseed payment is 433.5 ECU per hectare.[5] In addition, a compensation payment of 69.83 ECU/t multiplied by the regional cereals reference yields is paid on land which has been set-aside.

There have been several different studies which examine the impact of the per hectare compensation payments on crop mix (see Guyomard et. al. [1996] and Cahill [1997]). Each of these studies has shown that the per hectare compensation payments do have an effect on crop mix. However, since the primary purpose of these studies is to examine the overall impact of CAP reform on EU cropping patterns, it is not easy to separate the effects of price reductions and land set-asides from the impact of the compensatory payments. Therefore, a model of a very simplistic stylized version of the CAP has been developed for the purpose of this paper.

The following analysis attempts to isolate the effect of per hectare compensation payments on cropping decisions by developing a simple model of a producer who grows two types of crops: cereals (c) and oilseeds (o). The producer receives a fixed per hectare compensation payment, s_i, for each crop type which are independent of yields and specific to each crop. The producer is a price taker in the output and variable input markets. The producer's problem is to select the level of variable inputs, x_i, for each of the crop types (one variable input for each crop type is assumed in order to avoid jointness in production aside from a land constraint), and to allocate total land holdings (H-G) [6] among these crops. Total area is fixed at H and h_i is the area planted to crop i. The set-aside premium per hectare is g and the total land set aside is G. The production function by crop type is $f^i(h_i, x_i)$. Since production is equal to area times yield, $h_i \bullet y_i$, yield is defined as $y_i = f^i(h_i, x_i)/h_i$.

The producer's optimization problem is solved in Appendix C. The first order condition are described below after the first and second equations have been combined.

$$p_c \partial f^c / \partial h_c + s_c = p_o \partial f^o / \partial h_o + s_o$$
$$p_c \partial f^c / \partial x_c - w_c = 0$$
$$p_o \partial f^o / \partial x_o - w_o = 0$$
$$H - G - h_c - h_o = 0$$

The first equation states that the producer will assign the mix of land such that, profitability of a hectare of cereals, plus the per-hectare payment, will equal the profitability of a hectare of oilseeds plus the oilseeds per hectare payment. The first thing to note from this equation is that if the compensation payment s_i were not specific to a crop type, cereals or oilseeds, then the subsidy would cancel out. The next two equations equate the value of the marginal product of the variable inputs for each crop type, to the price of the inputs. The absence of the compensation payment s_i from these equations implies that input use, and hence yields, are

5. Revenue per hectare from these payments is 250 ECU/ha for cereals, 361 ECU/ha for protein crops, and 433.5 ECU/ha for oilseeds (which may be reviewed during the marketing year).
6. Where H is total hectares of arable land less G hectares of set-aside area.

independent of the payments. The final equation repeats the constraint on the total use of land. The other thing to note from these equations is that the set-aside premium per hectare, g, does not enter the producer's area allocation decision.[7]

For crops within the cereals grouping, such as wheat and barley, the per hectare compensation payments are the same and the effect on cropping mix should be neutral. The reform proposed in 1998 in Agenda 2000 proffers a non-crop specific area payment to be established at 66 ECU/t (multiplied by the regional cereal's reference yields of the 1992 reform). However, exceptions are still to exist for protein crops with a supplementary aid to be established at a level of 6.5 ECU/t "in order to preserve their competitiveness with cereals" and the current supplements for durum wheat will be retained.

The neutrality of non-crop specific payments is a direct result of the land constraint, which imposes interdependence in production (i.e., joint production). As we have seen previously in Chapter 2, non-jointness in production would imply non-neutrality of the non-crop specific payments. Does a joint production technology hold for European grains and oilseeds production? Is the assumption of a land constraint appropriate for individual producers in the European Union? And are there other reasons for jointness in production other than the land constraint and what are the implications for production? While no individual may face a land constraint, there is an aggregate land constraint on a regional or community wide basis.[8] Furthermore, regional expenditure constraints will play the same role as the land constraint in the optimization problem and will result in the neutrality of non-crop specific payments. Jointness in production will not always lead to the neutrality for non-crop specific payments when the jointness arises for other reasons besides a linear land constraint. For instance, if there are economies of scope[9] in the production of the different products, any assistance will increase the production of all products (Appendix B provides the details).

In order to determine the effect of s_c and s_o on the crop mix decision, it is necessary to do comparative statics on the first order conditions.[10] The results of this analysis are as expected: an increase in s_i increases the area allocated to h_i and decreases the area allocated to competing crops (provided that the production functions of both crops are concave).

Other practical considerations arise out of the European experience. Although regional base yields are set on a historic basis, they could be subject to future changes. So, if producers believe they can influence future regional base yields by increasing their current yields, the decoupling will not be effective. While this may not be a practical issue for the EU system of compensatory payments, a similar problem could arise for the US FAIR Act transition

7. This is a result of treating the set-aside as an exogenous amount. A more realistic approach would be to account for the fact that voluntary set-aside exists as well. If the level of set-aside, G, is endogenous, producers will set aside land until the per unit payment g equals the shadow value of the constraint λ.
8. The land constraint may not hold as an equality, as in our optimization problem, for there is reason to believe that land will not be held in agricultural production because of high opportunity costs for alternative uses. Furthermore, extensification payments for beef production and voluntary set-asides may draw land out of the production of cereals and oilseeds.
9. Economies of scope imply that two products can be produced together more cheaply than each can be produced independently.
10. See Appendix C for details.

payments which are based on individual yields. Decoupling will not hold whenever current producer reactions affect how future programs are developed and thereby affect the pay-outs that the producer will receive in the future.

A second issue surrounding EU compensation payments is that production is required to receive the payment. There are those that believe EU production would decline if continued farming were not required for compensation payments. This will only hold if the next best alternative for the land is non-agricultural or fallow. If the next best alternative is agriculture based and the land changes ownership to a more efficient producer, then output could increase. Ireland, France, Germany, and Finland impose restrictions on non-farmers from acquiring agricultural land. Denmark and France impose restrictions on maximum farm size.

Summary for EU Compensatory Payments

In summary, the European Union's program of arable compensation payments affect cropping patterns but do not appear to induce extra yields. The neutrality of the program, with respect to yields, depends upon the producer not being able to affect the size of his pay-out. If the producer anticipates that future extensions to the program will depend on his current behaviour, extra yields may be induced. The program is not neutral in the sense that pay-out also depends on the continuation of farming. The requirement to continue farming will lead to long-term increases in production if yields grow over time. Although the compensation payments are decoupled from yields, they still affect production decisions and producers, for the most part, still do not respond to market signals.

Chapter 4: Program Comparison

The previous analysis is somewhat contrived in that each program is assigned particular characteristics that all three programs probably share. The criticisms of decoupled payments also apply to EU compensatory payments and even to some extent to NISA. To the extent that each program reduces risk, it induces production. The wealth effect for a risk averse (expected utility of profits maximizing) producer will also induce production.

Of the three programs discussed, only NISA is a whole farm program, which addresses both livestock and crop production. The EU compensation payments are the most targeted because different subsidy levels apply to different crop groupings. In nominal terms, the U.S. FAIR Act contract payments are tied to specific crops through a historic base, but in real terms, the producer is free to choose any form of agricultural activity and still receive the contract payment. In general, the more broadly based the support is applied across activities, the more neutral the program. The only exception is where all the farm's enterprises exhibit economies of scope. Although this criticism could be directed at NISA, the effects should be limited because the limits on government-matched payments should preclude this economies of scope effect. The economies of scope effect would also be applicable to EU compensation payments even if the same payment applies to all activities.

The fact that a lump sum payment can affect production decisions for debt constrained farmers is more likely to apply in the case of small farms. To the extent that there are more small farms in the EU, this may present more of a problem in Europe. The government transfer provided by NISA should not be of much assistance in reducing debt constraints, for the savings aspect of the program increases the opportunity cost of expansion of productive assets.

The analysis presented above shows that none of the three programs is completely neutral. However, the green box criteria only require that a program have minimally trade or production distorting effects. Programs that are intended to redistribute income should comply as closely as possible with the principle of a lump sum transfer.[1] Programs which are intended to correct for market failures should attempt to correct for the underlying market failure. In a

1. See the companion paper J. Rude (1999) "Green Box Criteria: A Theoretical Assessment" for a fuller discussion of the role of lump sum transfers as a method of redistributing income.

practical sense, it is not usually possible to correct for a market failure at source or to transfer income in a completely neutral manner. Given these practical realities, the best type of government intervention minimizes the amount of discretionary power left to the individual so that they may not change their behaviour in order to take advantage of the intervention. The rules of thumb, which can be used to minimize the chance that individual agents will change their behaviour to take advantage of the government intervention, include:

- The intervention should take place after the individual has made a production decision.
- If the intervention is not targeted at one specific sector there is less chance for distortions, as market considerations should still determine the allocation of resources among sectors.
- If the individual is partially responsible for correcting for the failure there should be less incentive for individuals to change their behaviour in a manner unintended by the government.

The following table organizes each of the three programs in terms of these considerations:

Table 1: Program Characteristics

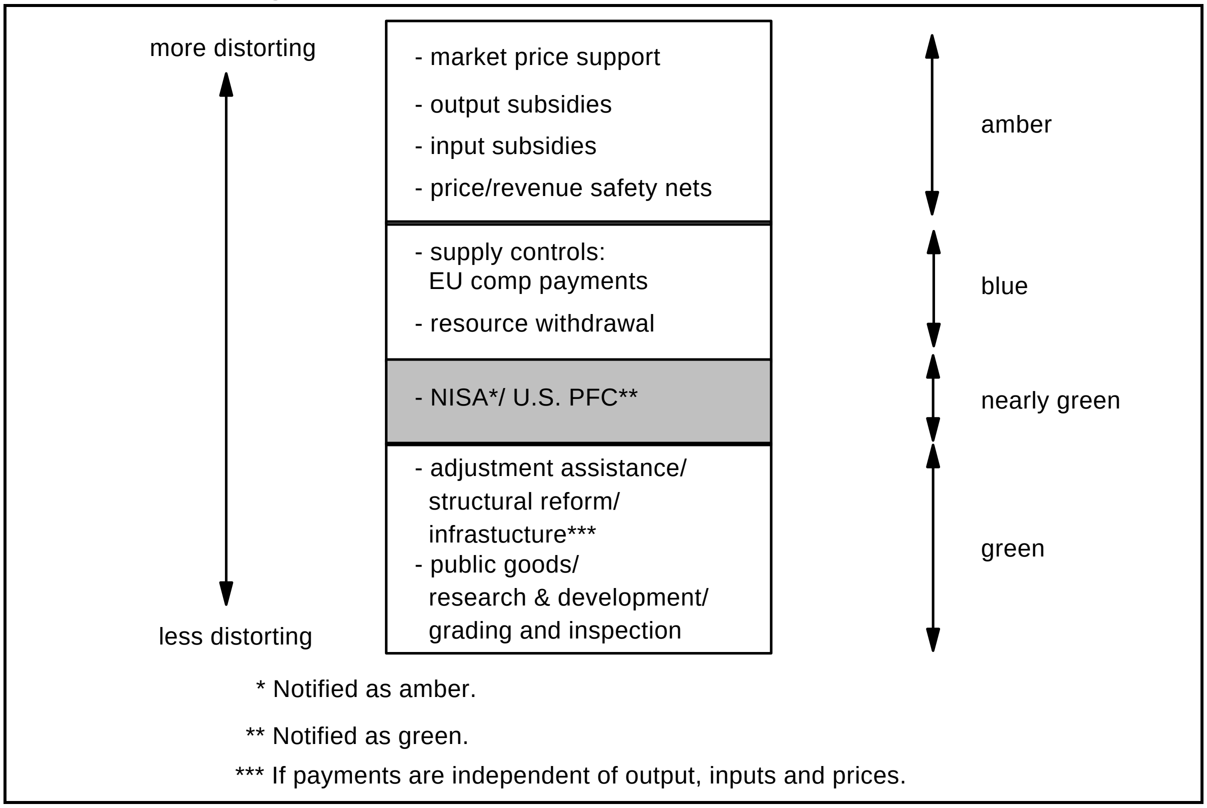
	Commodity specific	Recipients contribute	Ability to foresee payment	Payment criteria fixed	Off-setting Effects	Wealth Effects	May relax debt constraint
EU Comp. Payment	Targeted to crop types	No	Yes, choice of crop mix determines payment	No, can affect payment by choice of crop type	Limited—though land set aside	Yes	Yes
NISA	Generally available (crops, hogs, cattle, horticulture)	Yes	No, trigger provides ex post payout	Limited possibility to affect gov't. payment (if in Stage II)	Yes	Yes	Yes
U.S. PFC Payment	No, but past crop production is required	No	Yes, perfect foresight	Payment is fixed/not able to affect size of pay-out	No	Yes	Yes

Chapter 5: Program Classification

While no support program can ever be considered completely production neutral, some programs can be more distorting than others. From a practical perspective, governments have to consider certain trade-offs when designing programs. The program must be politically acceptable and administratively feasible. The program should be flexible enough to meet the specific needs of the individual country or region. These considerations will limit a government's scope for designing non-distorting programs. Given the practical limitations of designing non-distorting programs, there are certain prerequisites for an acceptable program. First, rents should accrue to producers and not to factors of production. Each of the three programs will result in a certain degree of capitalization of rents in fixed factors. The effect for NISA should be less than for the other two programs because the money is less easy to get at. Second, there should be financial ceilings for program expenditures. The large financial transfers involved in both the U.S. PFC payments and the EU compensatory payments may be problematic. Even if the programs such as the U.S. PFC payments are mostly neutral, the impacts of small effects can become greatly magnified when spread over a large program expenditure. Recently, the U.S. has provided "market loss" payments which are equal to fifty percent of 1988 PFC payments in compensation for the perceived farm crisis. The provision of this ad hoc support draws into question the neutrality program if participants can receive additional support on demand.

During the Uruguay Round negotiations, several authors (Miner and Hathaway [1988] and the IATRC [1990]) attempted to categorize domestic support policies on a subjective evaluation of their ability to distort trade. The following continuum, shown in figure 6, draws on the earlier categorization work and adds insights derived from this paper.

Figure 6: Spectrum for Potential to Distort Trade



It is difficult to assign NISA a precise spot within the green part of the spectrum. The program cannot be unconditionally declared neutral, because additional government contributions can be obtained through additional sales. But there are offsetting effects to this incentive effect. Moreover, the level expenditure is small, and the complexity of the program helps mitigate the incentive effects. The U.S. PFC program is also difficult to categorize although it is cleaner than NISA purely in terms of incentive effects. The biggest concerns with the program are the large dollar amounts of the payments, the expectation that production now may be required for a future generation of the program, and the recent use of the program to provide additional ad hoc transfers to producers. The EU compensatory payments clearly cannot be considered green in their current form.

Although green box programs are more benign than other forms of support, it is clear that large ongoing payments, by the amount of their size and permanence, attract or keep resources in agriculture. As the green box becomes a more popular avenue for governments to provide domestic support, the size of the expenditure envelope will expand and the potential for distortions will increase accordingly. Moreover, although programs may be designed to be production neutral, they are not always so in practice. Even though a program may be only marginally distorting, large program expenditures may turn a small distortion into a big impact. This raises the need for a cap on total green box spending, possibly combined with a cap on each element of the green box.

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Appendix A

Since NISA is a savings instrument, I have chosen to consider the program in a savings-consumption framework. Initially consider a producer who views the future with certainty and has a choice between current consumption and conventional savings (no special NISA program is in place). The producer maximizes utility, u, by allocating consumption of x over time subject to an income constraint. Savings (the difference between current income Pf(k) and current consumption x) are invested in either real assets, k, or bonds, B. His optimization problem is:

$$\max_{\mathbf{x}} \int_0^T e^{-rt} u\big(x(t)\big)\,dt$$

$$s.t.\ \dot{B} = P \cdot f\big(k(t)\big) - C\big(I(t)\big) - x(t) + B(t) \cdot i$$

$$\dot{k} = I(t) - d \cdot k(t)$$

$$k(0) = \overline{K} \quad k(T) \geq 0$$

$$B(0) = \overline{B} \quad B(T) \geq 0$$

where:

x(t) ≡ consumption at time t

I(t) ≡ investment in real assets at time t

C(I(t)) ≡ cost of acquiring real assets at time t

k(t) ≡ capital stock at time t

B(t) ≡ bond account balance at time t

i ≡ interest rate on bonds

ρ ≡ farmer’s personal discount rate or time preference

P ≡ output price

f(k) ≡ production function

δ ≡ depreciation rate on capital

The variables with bars on top are initial capital stocks and initial bond balances at time period 0. The variables with dots on top are time derivatives and represent the change in the stock variables between periods. This problem can be written as a control problem with a current value Hamiltonian H_c. The discounting factor has been incorporated into the co-state variables so they are current value multipliers. The time subscripts are suppressed below.

$$H_c = U(x) + l_B[P \cdot f(k) - C(I) - x + B \cdot i] + l_k[I - d \cdot k]$$

The principle marginal conditions are:

$$(1)\ \partial H_c / \partial x = U'(x) - \lambda_B = 0$$

$$(2)\ \partial H_c / \partial I = -\lambda_B C'(I) + \lambda_k = 0$$

$$(3)\ \dot{\lambda}_B = -\partial H_c / \partial B + \rho \lambda_B = -\lambda_B i + \rho \lambda_B$$

$$(4)\ \dot{\lambda}_k = -\partial H_c / \partial k + \rho \lambda_k = -\lambda_B P \frac{\partial f}{\partial k} + \lambda_k \delta + \lambda_k \rho$$

$$(5)\ \dot{B} = Pf(k) - C(I) - x + B \cdot i$$

$$(6)\ \dot{k} = I - \delta \cdot k$$

$$(7)\ \lambda_B \geq 0 \qquad \lambda_B \cdot B = 0$$

$$(8)\ \lambda_k \geq 0 \qquad \lambda_k \cdot k = 0$$

The term U' is the derivative of the utility function with respect to consumption. Equations 1 and 2 can be differentiated with respect to time and the resulting rates of change, $\dot{\lambda}_i$, and the definitions of λ_i from equations 1 and 2 can then be substituted into equations 3 and 4.

$$(3')\ U''(x) \cdot \dot{x} = U' \cdot (\rho - i)$$

$$(4')\ U'(x) \cdot C''(I) \cdot \dot{I} + U''(x) \cdot C'(I) \cdot \dot{x} = U' \cdot (x) \cdot C'(I) \cdot (\delta + \rho) - U'(x) P \frac{\partial f}{\partial k}$$

Equations 3' and 4' can be re-arranged so that $\dot{x}$ and $\dot{I}$ are on the left hand side. We now have a system of four differential equations (3', 4', 5 and 6) and four dot variables (k, B, x and I) which can be solved. However, without explicit information on functional forms, this system of equations is difficult to solve and interpret. In order to aid in the interpretation, consider the steady state solution where each of the dot variables: k, B, x and I are set to zero. Equations 3' and 4' become:

$$(3'')\ \rho = i$$

$$(4'')\ P \frac{\partial f}{\partial k} = (\delta + \rho) \cdot C'(I)$$

So in a steady state equilibrium, the market rate of interest will equal the farmer's time preference rate. Capital is acquired to the point where the value of the marginal product is equal to the user cost of capital.

In the next step, we will consider government contributions to NISA and the subsidized interest rate. For the time being, we will abstract from stochastic revenues and the mechanism which triggers NISA pay-outs. Government contributions can be up to three percent of eligible net sales. To account for these contributions, the equation of motion for bonds is augmented by the term 0.03•P•f(k). This assumes that producers adjust their NISA accounts to maximize government contributions[1]. The interest rate on NISA holdings is assumed to be the market rate of interest for bonds, i, plus a subsidy, s. The revised current value Hamiltonian is:

$$H_c = U(x) + l_B[P \cdot f(k) - C(I) - x + B \cdot (i+s) + 0.03 * P \cdot f(k)] + l_k[I - d \cdot k]$$

The revised principle marginal conditions are:

$$(9)\ \P H_c / \P x = U'(x) - l_B = 0$$
$$(10)\ \P H_c / \P I = -l_B C'(I) + l_k = 0$$
$$(11)\ \dot{l}_B = -\P H_c / \P B + r\, l_B = -l_B(i+s) + r\, l_B$$
$$(12)\ \dot{l}_k = -\P H_c / \P k + r\, l_k = -l_B[P\frac{\P f}{\P k} + 0.03 \cdot P\frac{\P f}{\P k}] + l_k d + l_k r$$
$$(13)\ \dot{B} = Pf(k) - C(I) - x + B \cdot i$$
$$(14)\ \dot{k} = I - d \cdot k$$
$$(15)\ l_B \geq 0 \qquad l_B \cdot B = 0$$
$$(16)\ l_k \geq 0 \qquad l_k \cdot k = 0$$

As with the first optimization problem, equations 9 and 10 can be differentiated with respect to time and the resulting rates of change, $\dot{l}_i$, and the definitions of λ_i from equations 9 and 10 can then be substituted into equations 11 and 12.

$$(11')\ U''(x) \cdot \dot{x} = U' \cdot (r - i - s)$$
$$(12')\ U'(x) \cdot C''(I) \cdot \dot{I} + U''(x) \cdot C'(I) \cdot \dot{x} = U' \cdot (x) \cdot C'(I) \cdot (d + r) - U'(x) \cdot 1.03 \cdot P \cdot \frac{\P f}{\P k}$$

Again, we have a system of four differential equations (11', 12', 13 and 14) and four dot variables (k, B, x and I). And again, in order to aid in the interpretation, we consider the steady state solution where each of the dot variables: k, B, x and I are set to zero. Equation 3" becomes 11" so that now $r = i$ +s which can be substituted into equation 12'.

$$(12'')\ 1.03 \cdot P\frac{\P f}{\P k} = (d + i + s) \cdot C'(I)$$

Equation 12' can be compared to equation 4" to gauge the impacts of NISA with matching government contributions and an interest rate subsidy.

$$\textbf{NISA:} \qquad\qquad \textbf{No Program:}$$
$$1.03 \cdot P\frac{\P f}{\P k} = (d + i + s) \cdot C'(I) \ ; \ P\frac{\P f}{\P k} = (d + i) \cdot C'(I)$$

1. I have set the problem up in an alternative manner with a separate NISA investment variable and a Lagrange constraint where 0.03*P*f(k) ≥ NISA investment. However, this optimalization problem produces the same results as shown in the text.

The matching government contribution increases the value of the marginal product of real assets, increasing the amount of capital which is employed in the steady state, and thereby increasing the level of production. However, there is a counteracting effect through the interest rate subsidy which increases the opportunity cost of investing in real assets. A complete answer requires a simultaneous solution to the four differential equations (11', 12', 13 and 14) which can then be compared to the solution to equations 3', 4', 5, 6.

To this point we have not considered the possibility that revenues may be uncertain. The introduction of stochastics does not allow us to set up the usual optimal control problem. Ito control simplifies the stochastic structure of the model and finds optimality conditions using a stochastic calculus.

The stock equations are modeled as stochastic differential equations:

$$ds = g(t, s, c)\,dt + \sigma(t, s, c) \bullet dz$$

Where: $s \equiv$ state variable
$c \equiv$ control variable
$dz \equiv$ increment of the stochastic process z that obeys Brownian motion

The term g(t,s,c) is the expected change in the state variable, or in our case, the expected change in bond accumulation. The term $\sigma(t, s, c)\bullet dz$ is the unexpected change in the state variable. The term z follows a Wiener process and $E(dz(t)) = 0$, $E(dz(t)^2 = dt$, and $E(dz(t)\bullet dz(\tau)) = 0$ (where time $t \neq \tau$). So the variance of the state variable, s, is equal to $\sigma(s)^2 dt$.

For our simple savings consumption decision, we will follow an example developed by Merton (1971) as described in Kamien and Schwartz (1991 p.p.269-270). Net revenues, P•f(k), are stochastic and can either take on a low state, *l*, or a high state, *h*. The low state is expected to occur with probability α, and the high state is expected to occur with probability (1-α). The expected value and variance of net revenues are:

$$E[P\bullet f(k)] = \alpha\bullet P\bullet f(k) \bullet l + (1-\alpha) \bullet P\bullet f(k) \bullet h$$
$$E[P\bullet f(k) - E(P\bullet f(k))]^2 = [P\bullet f(k)]^2 \bullet [1- \alpha \bullet l - (1-\alpha)\bullet h]^2 = P^2 \cdot f(k)^2 \cdot s^2$$

The change in bonds is given by:

$$dB = [\alpha\bullet P\bullet f(k) \bullet l + (1-\alpha)\bullet P\bullet f(k) \bullet h - C(I) - x + B\bullet i]\bullet dt + P\bullet f(k)\bullet \sigma\,[Pf(k)] \bullet dz$$

The change in the capital stock is assumed to be non-stochastic. The current value Hamiltonian (which parallels Bellman's equation as described on page 270 of Kamien and Schwartz) is:

$$H_c = U(x) + l_B[a \cdot P \cdot f(k) \cdot \ell + (1-a) \cdot P \cdot f(k) \cdot h - C(I) - x + B \cdot i] + l_k[I - d \cdot k]$$
$$+1/2 \cdot l_{BB} \cdot P^2 \cdot f(k)^2 \cdot s^2$$

The additional term in the current value Hamiltonian is analogous to the adjustment for risk preferences which is found in a static expected utility-maximization framework. The term λ_{BB} is the second derivative of the utility function with respect to bonds, U'', which is expected to be negative. The agent is therefore risk adverse. If U'' = 0, the agent would be risk neutral and the optimization would be the same as above.

The principle marginal conditions are:

$$(17)\ \partial H_c / \partial x = U'(x) - \lambda_B = 0$$
$$(18)\ \partial H_c / \partial I = -\lambda_B C'(I) + \lambda_k = 0$$
$$(19)\ \dot{\lambda}_B = -\partial H_c / \partial B + r\lambda_B = \lambda_B (r - i)$$
$$(20)\ \dot{\lambda}_k = -\partial H_c / \partial k + r\lambda_k = -[\lambda_B P \frac{\partial f}{\partial k} \cdot \alpha \cdot \ell + \lambda_B P \frac{\partial f}{\partial k} \cdot (1-\alpha) \cdot h]$$
$$+ \lambda_k \delta - \lambda_{BB} \cdot P^2 \cdot f(k) \cdot \frac{\partial f}{\partial k} \cdot \sigma^2 + \lambda_k r$$
$$(21)\ dB = [\alpha \cdot Pf(k) \cdot \ell + (1-\alpha) \cdot Pf(k) \cdot h - C(I) - x + B \cdot i]dt + P \cdot f(k) \cdot \sigma \cdot dz$$
$$(22)\ \dot{k} = I - \delta \cdot k$$
$$(23)\ \lambda_B \geq 0 \qquad \lambda_B \cdot B = 0$$
$$(24)\ \lambda_k \geq 0 \qquad \lambda_k \cdot k = 0$$

As above, equations 17 and 18 can be differentiated with respect to time, and the resulting rates of change, $\dot{\lambda}_i$, and the definitions of λ_i from equations 17 and 18 can then be substituted into equations 19 and 20.

$$(19')\ U''(x) \cdot \dot{x} = U' \cdot (r - i)$$
$$(20')\ U'(x) \cdot C''(I) \cdot \dot{I} + U''(x) \cdot C'(I) \cdot \dot{x} = U' \cdot (x) \cdot C'(I) \cdot (r + \delta)$$
$$-[U' P \frac{\partial f}{\partial k} \cdot \alpha \cdot \ell + U' P \frac{\partial f}{\partial k} \cdot (1-\alpha) \cdot h] - \lambda_{BB} \cdot P^2 \cdot f(k) \cdot \frac{\partial f}{\partial k} \cdot \sigma^2$$

Equations 19' and 20' can be re-arranged so that $\dot{x}$ and $\dot{I}$ are on the left hand side. We now have a system of four differential equations (19', 20', 21 and 22) and four dot variables (k, B, x and I) which can be solved. However, without explicit information on functional forms, this system of equations is difficult to solve and interpret. In order to aid in the interpretation, consider the steady state solution where each of the dot variables: k, B, x and I are set to zero. Equations 19' and 20' become:

$$(19'')\ r = i$$
$$(20'')\ P \frac{\partial f}{\partial k} \cdot (\alpha \cdot \ell + (1-\alpha) \cdot h) = (d + r) \cdot C'(I) - P^2 f \cdot \frac{\partial f}{\partial k} \cdot \sigma^2 \cdot \frac{\lambda_{BB}}{\lambda_B}$$

The addition of the risk premium to equation 20" increases the user cost of capital because $-P^2 f \bullet \frac{\partial f}{\partial k} \bullet \sigma^2 \bullet \frac{\lambda_{BB}}{\lambda_B} > 0$ since λ_{BB} is negative. As a result, less capital is employed than in the non-stochastic case (4").

The introduction of NISA can proceed as above. We will continue to abstract from the effect of the trigger mechanism, but account for government contributions to NISA and the subsidized interest rate. NISA will also affect the expected value and variance of net revenues. For simplicity we will assume that net revenues in the low income state are equal to expected revenues (from the no NISA case) and, therefore, expected net revenues with NISA will be higher than expected net revenues without NISA.

$$E(Pf(k))_N = \alpha \bullet E(Pf(k)) + (1-\alpha) \bullet Pf(k) \bullet h$$
$$= P \bullet f(k) \bullet [\alpha^2 \bullet l + (\alpha(1-\alpha)+(1-\alpha)) \bullet h]$$

Likewise, the variance of this truncated distribution is smaller than the variance without NISA.

$$E(Pf(k)-E(Pf(k))^2_N = P^2 \bullet f(k)^2 \bullet [1-\alpha^2 \bullet l-(1-\alpha)^2 \bullet h]^2 = P^2 \bullet f(k)^2 \bullet \sigma^2$$

The revised current value Hamiltonian is:

$$H_c = U(x) + l_B\Big[\ P \cdot f(k) \cdot [a^2 \cdot \ell + (a(1-a) + (1-a) \cdot h] + 0.03 * P \cdot f(k) \cdot [a \cdot \ell + (1-a) \cdot h]$$
$$- C(I) - x + B \cdot (i+s)\ \Big] + l_k[I - d \cdot k]\Big\{\ \ +1/2 \cdot l_{BB} \cdot P^2 \cdot f(k)^2 \cdot s^2{}_N$$

The maximum principle conditions are:

(25) $\P H_c / \P x = U'(x) - l_B = 0$

(26) $\P H_c / \P I = -\ l_B C'(I) + l_k = 0$

(27) $\dot{l}_B = -\P H_c / \P B + r\, l_B = l_B(r - i - s)$

(28) $\dot{l}_k = -\P H_c / \P k + r\, l_k = -\Big[\ l_B P \frac{\P f}{\P k} \cdot (a^2 \cdot \ell + (a(1-a) \cdot (1-a) \cdot h) + l_B \cdot (.03) \cdot P \frac{\P f}{\P k}$

$\cdot [a \cdot \ell + (1-a) \cdot h]\ \Big] + l_k d - l_{BB} \cdot P^2 \cdot f(k) \cdot \frac{\P f}{\P k} \cdot s^2_N + l_k r$

(29) $dB = \Big[\ Pf(k) \cdot (a^2 \cdot \ell + (a(1-a) \cdot (1-a) \cdot h) + (.03) \cdot P \cdot f(k) \cdot \cdot [a \cdot \ell + (1-a) \cdot h]$

$- C(I) - x + B \cdot i\ \Big] dt + P \cdot f(k) \cdot s_N \cdot dz$

(30) $\dot{k} = I - d \cdot k$

(31) $l_B \geq 0 \qquad l_B \cdot B = 0$

(32) $l_k \geq 0 \qquad l_k \cdot k = 0$

As above, equations 25 and 26 can be differentiated with respect to time, and the resulting rates of change, $\dot{l}_i$, and the definitions of λ_i from equations 25 and 26 can then be substituted into equations 28 and 29.

$$(28')\ U''(x)\cdot\dot{x} = U'\cdot(r - i - s)$$

$$(29')\ U'(x)\cdot C''(I)\cdot\dot{I} + U''(x)\cdot C'(I)\cdot\dot{x} = U'\cdot(x)\cdot C'(I)\cdot(r + d)$$

$$-[U'\cdot P\frac{\partial f}{\partial k}\cdot[\alpha^2\cdot\ell + (\alpha(1-\alpha) + (1-\alpha))\cdot h + U'\cdot .03\cdot P\frac{\partial f}{\partial k}\cdot(\alpha\cdot\ell + (1-\alpha)\cdot h)]$$

$$-\lambda_{BB}\cdot P^2\cdot f(k)\cdot\frac{\partial f}{\partial k}\cdot\sigma_N{}^2$$

Imposing a steady state for equations 28' and 29' become:

$$(28'')\ r = i + s$$

$$(29'')\ P\frac{\partial f}{\partial k}\cdot[\alpha^2\cdot\ell + (\alpha(1-\alpha)\cdot(1-\alpha)h] + 0.03\cdot P\frac{\partial f}{\partial k}\cdot[\alpha\cdot\ell + (1-\alpha)\cdot h]$$

$$= (d + i + s)\cdot C'(I) - P^2 f\cdot\frac{\partial f}{\partial k}\cdot\sigma_N{}^2\cdot\frac{\lambda_{BB}}{\lambda_B}$$

For a partial description of the effect of NISA we can compare equations 29" and 20":

$$(20'')\ P\frac{\partial f}{\partial k}\cdot(\alpha\cdot\ell + (1-\alpha)\cdot h) = (d + r)\cdot C'(I) - P^2 f\cdot\frac{\partial f}{\partial k}\cdot\sigma^2\cdot\frac{\lambda_{BB}}{\lambda_B} \quad \Longleftrightarrow$$

$$(29'')\ P\frac{\partial f}{\partial k}\cdot[\alpha^2\cdot\ell + (\alpha(1-\alpha)\cdot(1-\alpha)h] + 0.03\cdot P\frac{\partial f}{\partial k}\cdot[\alpha\cdot\ell + (1-\alpha)\cdot h] = (d + i + s)\cdot C'(I) - P^2 f\cdot\frac{\partial f}{\partial k}\cdot\sigma_N{}^2\cdot\frac{\lambda_{BB}}{\lambda_B}$$

As above, the effect of NISA is ambiguous because the interest rate subsidy, s, encourages less capital while the government contribution encourages more use of capital. The introduction of stochastic considerations are both effects that encourage capital accumulation. The expected value of net revenues $E(Pf(k))_N$ increases while $\sigma_N{}^2$ is smaller than σ^2. Both of these considerations should increase the desired capital stock and increase production.

Appendix B

To the extent that there is a production enhancing effect for NISA (i.e., 0.03*VMP_k > interest rate subsidy) the effect can be described in a static setting for a single commodity. The τ term is true net subsidy element of NISA, x-percent of eligible sales contributed by government. The single output farm's optimization problem is:

$$\max_Q \; P \bullet Q - C(Q) + \tau \bullet (P \bullet Q)$$

$$\text{foc:} \quad P(1+\tau) = \partial C / \partial Q$$

$$MR(1+\tau) = MC$$

In a multiple output setting, the ingredient which determines the effect of the subsidy on output is whether production of output is joint or non-joint. Non-joint production is a situation where the production of one good does not affect the production of other goods. For two good cases with non-joint production, the farm's optimization problem is:

$$\max_Q \; P_1 \bullet Q_1 + P_2 \bullet Q_2 - C_1(Q_1) - C_2(Q_2) + \tau \bullet (P_1 \bullet Q_1 + P_2 \bullet Q_2)$$

$$\text{foc:} \quad P_1(1+\tau) = \partial C_1 / \partial Q_1$$

$$P_2(1+\tau) = \partial C_2 / \partial Q_2$$

The result for a non-joint production function with two outputs is the same as for the single product case. Joint production implies that the production of one good affects the production of other goods. This jointness can occur for several reasons. First, there may be a constraint of a shared input such as land. In the EU section above, we saw that when there is a linear constraint on a shared input, the effects of a subsidy cancel out. However, this is not the only type of jointness which can occur. Panzar and Willig (1979) examine interdependent production using the concept of a public input. Inputs are said to be public when, as they are acquired to produce one good, they are available costlessly to other production processes. Jointness, in production, can be defined by the cross effects of output changes on the cost function. A joint cost function will depend on the outputs of all goods. So, for example, in our simple problem the cost function is $C(Q_1, Q_2)$. The cost function can exhibit complementaries, substitutability or non-jointness:

$$\partial^2 C / \partial Q_2 \partial Q_1 \gtreqless 0$$

An example of cost complementaries would be a situation where NISA allows a producer to reallocate his portfolio, invest in a larger tractor or better equipment, lower his costs and, as a result, produce more of all crops. Cost complementaries can also be thought of as economies of scope.

For two good cases with joint production, the farm's optimization problem is:

$$\max_{Q1\ Q2} \quad P_1 \bullet Q_1 + P_2 \bullet Q_2 - C(Q_1,Q_2) + \tau \bullet (P_1 \bullet Q_1 + P_2 \bullet Q_2)$$

$$\text{foc:} \quad P_1(1+\tau) = \partial C(Q_1,Q_2)/\partial Q_1$$

$$P_2(1+\tau) = \partial C(Q_1,Q_2)/\partial Q_2$$

In order to determine the effect of the subsidy with cost complementaries or substitutability, it is necessary to do comparative statics on this system of first order conditions. Totally differentiating this system, the result is (assuming that prices are exogenous and therefore constant):

$$P_1 d\tau = \partial^2 C/\partial Q_1^2 \bullet dQ_1 + \partial^2 C/\partial Q_1 \bullet \partial Q_2 \bullet d\, Q_2$$

$$P_2 d\tau = \partial^2 C/\partial Q_1 \bullet \partial Q_2 dQ_1 + \partial^2 C/\partial Q_1^2 \bullet d\, Q_2$$

Re-writing this system in matrix notation and changing the notation on the second derivatives of the cost function such that the derivatives are represented by subscripts (note Young's Theorem ensures that $C_{ij} = C_{ji}$):

$$\begin{bmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{bmatrix} \bullet \begin{bmatrix} dQ_1 \\ dQ_2 \end{bmatrix} = \begin{bmatrix} P_1 dt \\ P_2 dt \end{bmatrix}$$

$$\frac{dQ_1}{dt} = \frac{(P_1 C_{11} - P_2 C_{12})}{(C_{11} C_{22} - C_{12}{}^2)}$$

The sign of $dQ_1/d\tau$ depends on the sign of C_{12}. We will assume away increasing returns to scale so that C_{ii} will be positive and concavity of the cost function ensures that $C_{11}C_{22}$ is greater than C_{12}^2 so the denominator will be positive. The sign of the numerator will depend on the sign of C_{12} such that if there are cost complementaries, $C_{12}<0$, the sign of $dQ_1/d\tau$ will always be positive. If the cost function exhibits substitutability $C_{12}>0$ then the second term in the numerator will reduce the size of $dQ_1/d\tau$ (possibly even making it turn negative).

Appendix C

The producer's constrained maximization problem is:

$$\max_{h,x,\lambda} \prod = p_c y_c h_c + p_o y_o h_o - w_c x_c - w_o x_o + s_c h_c + s_o h_o + \lambda(H - G - h_c - h_o) + gG$$

Substituting the definition of yields, the optimization problem becomes:

$$\max_{h,x,\lambda} \prod = p_c f^c(x_c h_c) + p_o f^o(x_o h_o) - w_c x_c - w_o x_o + s_c h_c + s_o h_o + \lambda(H - G - h_c - h_o) + gG$$

The first order conditions for the maximization of the profit equation with respect to the inputs x and h and the Lagrange multiplier λ are:

$$p_c f^c{}_{hc} - \lambda + s_c = 0$$
$$p_o f^o{}_{ho} - \lambda + s_o = 0$$
$$p_c f^c{}_{xc} = w_c$$
$$p_o f^o{}_{xo} = w_o$$
$$H - G = h_c + h_o$$

In order to economize on space, the partial derivatives are denoted with subscripts so, for example, $\partial f^c / \partial h_c$ is written as $f^c{}_{hc}$. Combining the first two equations of the first order conditions and totally differentiating the resulting system is:

$$p_c f^c{}_{hchc} dh_c + p_c f^c{}_{hcxc} dx_c - p_o f^o{}_{hoho} dh_o - p_o f^o{}_{hoxo} dx_o = ds_o - ds_c$$
$$p_c f^c{}_{xchc} dh_c + p_c f^c{}_{xcxc} dx_c = dw_c$$
$$p_o f^o{}_{xoho} dh_o + p_o f^o{}_{xoxo} dx_o = dw_o$$
$$dh_o + dh_c = dH - dG$$

The comparative statics that we are interested in are dh_i/ds_i and dh_i/ds_j

$$\frac{dh_c}{ds_c} = \frac{|Z^{hc}{}_{sc}|}{|Z|} \qquad \frac{dh_c}{ds_o} = \frac{|Z^{hc}{}_{so}|}{|Z|}$$

where:

$$|Z| = \begin{bmatrix} p_c f^c{}_{hchc} & -p_o f^o{}_{hoho} & p_c f^c{}_{hcxc} & -p_o f^o{}_{hoxo} \\ p_c f^c{}_{xchc} & 0 & p_c f^c{}_{xcxc} & 0 \\ 0 & p_o f^o{}_{xoho} & 0 & p_o f^o{}_{xoxo} \\ 1 & 1 & 0 & 0 \end{bmatrix}$$

$$|Z^{hc}{}_{sc}| = \begin{bmatrix} -ds_c & -p_o f^o{}_{hoho} & p_c f^c{}_{hcxc} & -p_o f^o{}_{hoxo} \\ 0 & 0 & p_c f^c{}_{xcxc} & 0 \\ 0 & p_o f^o{}_{xoho} & 0 & p_o f^o{}_{xoxo} \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

$$\frac{dh_c}{ds_c} = \frac{-ds_c \cdot p_c f^c{}_{xcxc} \cdot p_o f^o{}_{xoxo}}{\Delta}$$

where:

$$\Delta = -[p_o f^o{}_{hoxo}]^2 \cdot p_c f^c{}_{xcxc} - [p_c f^c{}_{hcxc}]^2 \cdot p_o f^o{}_{xoxo} + p_c f^c{}_{hchc} \cdot p_c f^c{}_{xcxc} \cdot p_o f^o{}_{hoxo} + p_o f^o{}_{hoho} \cdot p_c f^c{}_{xcxc} \cdot p_o f^o$$

In order to determine the sign of dh_c/ds_c, it is necessary to determine the signs of the second derivatives of the production function for each crop $f^i{}_{ij}$. The $f^i{}_{ii}$s are all negative implying that production increases at a decreasing in inputs. For example $f^i{}_{hi\,hi}$ is change in yields for crop 1 for an increase in the area of crop 1 and the sign is negative. Furthermore, the concavity of the production function requires that $\partial^2 f/\partial h^2$ is greater than or equal to $\partial^2 f/\partial h \partial x$ and that $\partial^2 f/\partial x^2$ is greater than or equal to $\partial^2 f/\partial h \partial x$. These conditions are sufficient to ensure that the denominator Δ is negative. The numerator will be negative since prices are positive. The second derivatives of the production function $f^i{}_{xi\,xi}$ and the negative sign in front of the expression is negative. The sign of dh_c/ds_c is positive since both the numerator and the denominator are negative.

$$|Z^{hc}{}_{so}| = \begin{bmatrix} ds_o & -p_o f^o{}_{hoho} & p_c f^c{}_{hcxc} & -p_o f^o{}_{hoxo} \\ 0 & 0 & p_c f^c{}_{xcxc} & 0 \\ 0 & p_o f^o{}_{xoho} & 0 & p_o f^o{}_{xoxo} \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

$$\frac{dh_c}{ds_o} = \frac{ds_o \cdot p_c f^c{}_{xcxc} \cdot p_o f^o{}_{xoxo}}{\Delta}$$

The sign of dh_c/ds_o is negative since the denominator is negative and the numerator is positive.

A similar set of calculations can be done for the area decision for oilseeds and the effect of the own per hectare compensation payment is positive and the effect of the competing crop per hectare compensation payment is negative.