**WP 2001-16**

**August 2001**


# Working Paper

Department of Applied Economics and Management
Cornell University, Ithaca, New York 14853-7801 USA

# Disentangling the Consequences of Direct Payment Schemes in Agriculture on Fixed Costs, Exit Decisions and Output

**Nancy H. Chau and Harry de Gorter**

It is the Policy of Cornell University actively to support equality of educational and employment opportunity. No person shall be denied admission to any educational program or activity or be denied employment on the basis of any legally prohibited discrimination involving, but not limited to, such factors as race, color, creed, religion, national or ethnic origin, sex, age or handicap. The University is committed to the maintenance of affirmative action programs which will assure the continuation of such equality of opportunity.

It is the Policy of Cornell University actively to support equality of educational and employment opportunity. No person shall be denied admission to any educational program or activity or be denied employment on the basis of any legally prohibited discrimination involving, but not limited to, such factors as race, color, creed, religion, national or ethnic origin, sex, age or handicap. The University is committed to the maintenance of affirmative action programs which will assure the continuation of such equality of opportunity.

# Disentangling the Consequences of Direct Payment Schemes in Agriculture on Fixed Costs, Exit Decisions and Output

Nancy H. Chau*

Harry de Gorter†

This version: July 2001

**Abstract:** This paper goes beyond orthodox considerations of direct payment effects on agricultural output, by highlighting the role of subsidies in affecting individual producers' ability to cover fixed costs, and in distorting the volume of aggregate production and net trade by implicitly discouraging exits. The theoretical model considers both taxpayer and consumer financed decoupled direct payment schemes and compares them to a coupled production subsidy. In terms of possible producer responses to direct payments, we propose an analytical framework of production decision-making in the presence of a stochastic distribution of fixed costs across representative farms. We show that decoupled payments in theory can have a larger effect on output than coupled payments. The model explicitly recognizes three consequences of domestic support: (a) induce exit or entry; (b) bias production incentives to domestic markets; and (c) cross-subsidize export in global markets. An empirical model of the U.S. wheat sector is developed to illustrate the relative potential impacts of coupled versus decoupled payments on output through the effects on a farmer's ability to cover fixed costs and hence exit decisions.

JEL Classification: F16, J58

Keywords: Direct Payment Schemes, Decoupled and Coupled Support, Exit Decisions, Output and Exports.

# 1 Introduction

Agricultural support programs designed to protect farmers have undergone major reforms worldwide since the inception of the Uruguay Round of trade negotiations in the mid 1980s. The impetus for these reforms included the economic inefficiencies and budget costs generated by these programs, in addition to international pressures to minimize trade distortions (Gardner 2000). United States major field crops policy (Gisser 1993) has undergone significant changes since the 1985 Farm Bill where program yields were "frozen", thereby starting the trend towards decoupling of the target price that was finalized in the 1996 FAIR Act.[1] Likewise in the European Union, partially decoupled programs for major agricultural sectors were implemented through supplementary direct income payments (Cahill 1997). This program was initiated in the McSharry reforms of the early 1990s, and broadened in the EU's Agenda 2000 of the recent Berlin Accord. Canadian agricultural policy has also undergone major changes for a subset of the protected sectors, terminating several programs and replacing them with direct income support payments (Brink 2000).[2]

The effect of domestic subsidy programs on world trade has become an important policy issue, not least for the current agricultural trade negotiations. In an unprecedented act, WTO disciplines on agricultural support include domestic programs that encourage production. In particular, "amber" and "green" policy "boxes" are used to differentiate those policies that seriously distort trade from those with minimal trade effects. A key issue in the current World Trade Organization negotiations on agriculture will be the domestic support reduction commitments (measured by the "aggregate measure of support" or AMS) and the determination of which policies go in the "green" versus "amber" or "blue" box categories. Given the reform efforts of governments in agricultural policies for efficiency concerns and the ongoing trade negotiations, it has become increasingly important to understand the effect of farm programs on output response (OECD 2000, Blandford 2000). This is particularly true when the degree of

[1]The loan rate remains fully coupled, however, through "loan deficiency payments".

[2]For example, the Agricultural Stabilization Act (ASA), the Western Grain Stabilization Act (WGSA) and subsidies under the Western Grain Transportation Act (WGTA) have been terminated, and the National Tripartite Stabilization Program (NTSP) and the Gross Revenue Insurance Program (GRIP) are being phased out.

decoupling has become murky (Schmitz and Vercammen 1995). Many policies involve transfers from consumers or taxpayer financed income payments that are partially decoupled, such as support programs characterized by fixed payment yields, along with payments based on both acreage planted and acreage diverted. This trend towards varying degrees of decoupled policies thus stand in sharp contrast to more traditional agricultural policies that were fully coupled with import barriers, or provided open ended price supports or export subsidies.

The purpose of this paper is to identify the impacts of taxpayer and consumer financed infra-marginal production subsidies to farmers through the effects on farmers' ability to cover fixed and / or variable costs. Coupled support can be financed from either taxpayers or consumers, or a combination as in the case of export subsidies. Decoupled support can come in the form of infra-marginal production subsidies[3] financed either by consumers (e.g., U.S. peanut program or EU sugar quotas and supply management schemes in Canada)[4] or taxpayers (former U.S. crop deficiency payments with frozen program yields and fixed acreage base or compensatory payments currently in the EU). In particular, income transfers to farmers like the peanut quota, base acreage and direct income payments for wheat, or explicit coupled production subsidies can improve farmers ability to cover fixed and variable costs, thereby allowing a farmer who will otherwise exit the industry to stay in business, and perhaps even expand output beyond the quota or base acreage.[5] In this light, we identify production related factors that impact the magnitude of necessary transfers and prioritize various means of subsidy finance, such as consumer financed subsidies via trade measures,[6] or taxpayer financed subsidies via direct payments.

[3]"Infra-marginal" means the marginal cost for output receiving income payments is below the world price and farmers may or may not have to produce in order to receive payments (an example of not having to produce is the production flexibility contract payment scheme of the 1996 U.S. FAIR Act).

[4]Standard analysis of consumer financed infra-marginal subsidies for the U.S. peanut sector (with and without quota transfers) is given by Borges and Thurman (1994), Rucker and Thurman (1990), and Rucker, Thurman and Sumner (1995) and for the U.S. dairy sector by Wolf and Sumner (1996).

[5]The approach also allows for the potential effect of decoupled payments on investment, given the specialized skills of farmers and imperfect labor, information and capital markets (Roberts 1997, Skees 1999).

[6]Consumer financed infra-marginal production subsidies are unique in that it involves price discrimination and so requires import controls and an additional trade distortion not applicable to taxpayer financed infra-marginal production subsidies. This may have implications for trade law.

In addition to standard coupled subsidies, one can identify three broad categories of policies that encompass most "direct farm income payment schemes" in agriculture worldwide of infra-marginal income payments (e.g., ABC quotas for sugar in EU, peanut quota in the US and fluid milk quotas in California): (i) infra-marginal taxpayer financed income payment (former US crop policy with fixed payment yield and base acreage); (ii) infra-marginal direct income payment with a fixed per unit production subsidy financed by taxpayers (e.g., EU oilseeds and cereals), and (iii) infra-marginal income payments financed by taxpayers but the income payments are fixed per farm (based on historical production) but farmers do not have to produce to get payments (e.g., current U.S. production flexibility contract payments).

Our focus on this paper is to develop a generalized model of how payments can affect impact farmers' ability to cover costs and so to further our understanding of the importance of domestic support programs on global competitiveness. To this end, we develop a framework isolating factors affecting the competitiveness of agriculture and compare consumer and taxpayer financed infra-marginal production subsidies. Examples of these two major categories of domestic farm support are direct payments from taxpayers (e.g. production flexibility contract (PFC) payments for wheat) and consumer transfers with price supports (peanuts). We therefore isolate the production response of income transfers depending on whether it is taxpayer or consumer financed, making use of a model that explicitly recognizes several consequences of domestic support payments: (a) induce exit or entry; (b) bias production incentives in domestic markets; and (c) cross-subsidize export in global markets.

In this context, the urgent issue facing policy makers is to prioritize policies as to their impact on exports. Different types of domestic policies have differential effects on the level of farm income and production costs, thus affecting exit/entry and/or production beyond domestic use in cross-subsidizing exports. The value-added of this research paper is to provide a coherent framework that makes explicit the role of farm support in world trade, and to develop relevant criteria on how programs can be classified in order to improve the effectiveness of current domestic support policies. The empirical framework will involve calibrating the production and cost structure of a typical farm type for the U.S. wheat sector to illustrate the usefulness of the analysis and how outcomes depend on, inter alia, prices, demand, and cost variables specific to the industry in question. Empirical simulations of the relevant criteria that link global trade competitiveness with domestic farm support will aid in understanding the relative effects of the various factors identified.

## 2 Background

The importance of direct payments is emphasized by the fact that total support to agriculture has in fact increased during the implementation period of the Agreement on Agriculture (OECD 2001). In the United States, taxpayer financed subsidies to the U.S. crop sector averaged $18.3 billion from 1998 - 2000 (Table 1). Fully coupled loan deficiency payments (LDPs) and decoupled production flexibility contract payments (PFCs) represent a significant proportion of total payments, respectively. Decoupled payments are distinct from fully coupled LDPs in that the former is allocated independent of the cropping decision of the farmer. For instance, the 1996 Farm Act provides decoupled income support payments to farmers who enrolled into production flexibility contracts (PFCs) for seven years (1996 - 2002) in 1996.[7] These payments are not linked to current market prices and are presumed to have little or no direct effect on production decisions. Further, benefits of the program are tied to the land,[8] and farmers have flexibility in what and how much to plant, except for some limitations on planting fruits and vegetables. There are implicit costs to remaining eligible to receiving payments, however, in that recipients of the PFC payments may not use contract acreage for nonagricultural commercial or industrial purposes. Tables 2 and 3 give the operating costs of U.S. wheat production per farm and per acre, respectively. Average PFC and LDP payments constitute close to 14 and 6% of the total cash expense of the average wheat farm.

Consumer financed infra-marginal production subsidies may also be referred to as decou-

[7]It should also be noted that the Market Loss Assistance (MLA) program due to the Omnibus Appropriation Bill (1999) in the U.S. also made payments in fixed proportions to PFCs (50% in 1999 and 100% in 2000). Since MLA payments are also not contingent upon production levels or prevailing prices, the PFCs we consider here can also apply to the case of MLAs.

[8]Eligibility requires: (i) land is enrolled in acreage reduction programs for any of the crop years 1991 through 1995; (ii) land is planted to program crops under program rules; or (iii) land is enrolled in the Conservation Reserve Program (CRP) and had a crop acreage base associated with it.

pled payments. Like peanut and sugar quotas in the United States and the European Union, respectively, and supply management programs in Canada, consumer financed infra-marginal production subsidies can act like an export subsidy because of higher domestic prices imply a decrease in consumption and production expands because infra-marginal payments improve farmers' ability to cover costs.[9] Table 2 presents the fixed cost break down for the U.S. peanut sector. Domestic prices are over 50 percent higher than world prices.

We begin with a graphical exposition of a number of key consequences of direct payments that will be explored formally in the sequel. In particular, assuming that direct payments are fully de-coupled in the traditional sense as in Figure 1, point $a$ is always to the right of point $b$ in each panel of Figure 1 for the case of U.S. peanuts and wheat. Hence, the effects of a consumer transfer policy on demand and consequently on trade distortion is straightforward from panel (a) of Figure 1.[10] $\underline{Q}$ is the peanut quota with an associated domestic price $\bar{p}_d$, $p_s$ is the wheat target price, $sp_w$ is the per unit production subsidy for wheat, and $\underline{B}$ is the wheat base acreage. Transfers are area c in panel (a) and area $c$ and $d$ in panel (b). Since neither of these two policies affect production decisions at the margin, the effects on production are indirect in that farmers' ability to generate enough revenue to cover costs is affected.

To motivate the effect of the income payment on output through its effect on exit, consider a payment base $B$ in Figure 2 for a small country exporter with payments equal to the sum of area $a$ and $b$. World price ($p_w$) is below average total costs ($ATC^*$) so this farmer would ordinarily exit the industry and produce nothing. We can distinguish between three discrete production outcomes that can result in the presence of direct income payments: $Q^*, B$ or $O$ in Figure 2. First, if ATC is high enough at $B$ (say $ATC'_B$), it makes little sense for the farmer to produce $B$ if $ATC'$ is greater than $\bar{p}_d$. In addition, the farmer is in fact better off exiting the industry if total revenue net of total variable cost at $Q^*$ (area $a$, $b$, $c$, $d$, $e$ and $g$) is

[9]The recent WTO Dispute Settlement Panel on Canadian dairy policy illustrates the issues related to consumer financed infra-marginal subsidies where the Panel ruled that milk sold at the world price below domestic prices was an export subsidy for reasons other that that discussed in this paper. For a critique on the WTO ruling, see Schluep and de Gorter (2001) and Annad, Buckingham and Kerr (2001).

[10]We assume the right to income payments is freely tradable across farms.

less than total fixed cost (area $a'$, $a$, $b$, $c$ and $d$), or equivalently, area $e$ and $g$ is less than area $a'$.

Second, if $ATC$ is given by $ATC_B < \bar{p}_d$, fixed costs (and variable costs at $B$) are more than covered if the farmer produces at $B$, since total fixed cost is equal to area $b$, $c$ and $d$, while consumer (or taxpayer) financed subsidies raises revenue above market returns at point $B$ by area $a$, $b$ and $c$. The farmer will produce no more than $B$, however, if world price is lower than $p'_w$ in Figure 2.[11] Profits are thus given by exactly the area $a$.

Third, given that fixed cost (area $b$, $c$ and $d$) is now covered, and that it is profitable to produce at point $B$, it will also be profitable to produce up till the point $Q^*$, where the world price is equal to the marginal cost. Output exceeds payment base $B$, and consumer financed infra-marginal subsidies give rise to strictly positive exports whenever world price $p_w$ is higher than $p'_w$ – the marginal cost of production at $B$. Specifically, given an average total cost curve $ATC$ in Figure 2 (a), total profits at $Q^*$ are given by area $a$, $e$ and $g$. Area $a$ represents consumer-financed surplus up till the base $B$. Area $g$ represents the variable profits from exports, as world price $p_w$ exceeds average variable cost at $Q^*$. Area $e$ can be interpreted as gains from raising output beyond $B$ due to increasing returns (downward sloping average cost). Thus, profits are positive even though average total cost evaluated at $Q^*$ is strictly higher than the world price ($AVC^* > p_w$), and profits are in fact negative in the absence of the target price (area $c$ and $f$).

Two points deserve particular attention. First, it is easy to verify that profits need not be positive at $B$ in order for the target price to cross-subsidize exports. Consider once again the average total cost and average variable cost curves $ATC'$ and $AVC$ in Figure 2 a. Total profits are clearly negative at $B$ since $ATC'$ exceeds $\bar{p}_d$. However, if area $a'$ is less than the gains from increasing returns (area $e$), plus variable profits from exports (area $f$), the farmer is better off remaining in business and produce $Q^*$. Second, world price $p_w$ need not even exceed average variable cost at $Q^*$ in order for the target price to cross-subsidize exports. This is

[11] In particular, since $p'_w$ is just the marginal cost of production evaluated at the payment base $B$, if world price is less than $p'_w$, producing beyond $B$ can only lower profits as marginal cost exceeds the world price.

shown in panel $b$ of Figure 2. In particular, note that profits at $B$ are given by area $a$, and profits at $Q^*$ is given by area $a$, $d$ minus $f$. Thus, if area $a$ and $d$ exceed area $f$, it makes little sense for the farmer to exit. Additionally, if the gains from increasing returns as given by area $d$ for all $B$ units of output exceeds variable profit losses from exporting an additional $Q^* - B$ amount (area $g$), the farmer maximizes profits by producing at $Q^*$.

By allowing profits from one operation (domestic sales) to offset losses from another (exports), cross-subsidization occurs only if the world price is greater than $p'_w$ in Figure 2. The question arises: why would a firm want to finance losses in one operation with profits from another operation? From our discussion of Figures 2 (a) and (b), the answer to this question is in fact surprisingly simple. So long as farmers operate at the downward sloping portion of the $ATC$ curve, there are clear increasing returns to scale. This allows negative profits to be possible at low levels of production (at $B$, for example), but profits can nevertheless change sign at output levels high enough for exports ($Q^* - B$) to occur in the presence of consumer financed support (or production beyond base for taxpayer financed support) if either: (i) farmers are guaranteed a higher price at low levels of output, or (ii) decoupled direct payments effectively improve farmers' ability to cover costs, and deter incentives to exit the industry when world prices are low.

Should such programs be explicitly recognized as cross-subsidizing exports? Perhaps more importantly, how significant are these effects relative to subsidies that are traditionally considered as coupled, and therefore, directly trade distorting? This is an important issue, given the many sectors with such programs in the United States, European Union and Canada, especially given the recent WTO Panel decision on Canadian dairy pricing being an export subsidy (Schluep and de Gorter 2001). In this paper, a general methodology is developed to show the conditions under which a firm would choose each of the three options, the degree of distortion (relative size of $B$ versus $Q^*$, the slope of the marginal cost curve, the level of fixed costs to total costs, the level of payments, etc.). We then evaluate industry output in the aggregate and analyze the distribution of cost structures and farm sizes to link conditions determined for an individual firm to aggregate industry output.

## 3 The Basic Model

### Production

We consider an economy in which a large number $(N)$ of producers are engaged in the production of an output $x$. Individual producers are endowed with production technologies: $x = G(L_x)$. $G(\cdot)$ is taken to be strictly concave and twice continuously differentiable in a composite variable input $(L_x)$. We assume that perfect competition prevails in factor and output markets, and producers take factor rewards $w$ along with world price $p_w$, as exogenously given. Define the variable cost function of an individual producer as $C(x)$. The total cost function is given by

$$C(x) + F = \min_{L_x} wL_x + F, \quad s.t.\ G(L_x) \geq x.$$

$F \in [F^-, F^+]$ is taken to be a firm specific fixed cost parameter. The distribution of the $N$ firms in the range $F \in [F^-, F^+]$ is given by a cumulative distribution function $\mu(F)$, with $\mu'(F) \geq 0$.

### Consumption

Consumption demand for $x$ in the economy is characterized by an inverse demand function $p_d(D)$, with $p_d'(D) \leq 0$, where $D$ denotes domestic consumption. Let the associated elasticity of demand $-d \log p_d / d \log D$ be denoted as $\eta$. The link between domestic consumer price $p_d$ and world price $p_w$ depends on the commercial policy regime. In particular, let $\bar{p}_d$ be a target price on domestic sales. With $\widehat{N}$ number of producers operating at strictly positive output levels, the associated payment base $B$ of each representative producer is implicitly given by $\bar{p}_d = p_d(\widehat{N}B)$.

### Profits and Exit

The two-stage profit maximization problem of an individual entrepreneur involves: (i) the decision as to whether or not to incur the fixed cost $F$, and (ii) the choice of an output level given the competitive market returns to factor inputs, along with domestic $\bar{p}_d$ and world price $p_w$. We begin with the second stage problem. Let the magnitude of coupled and decoupled taxpayer financed income support be given by an ad valorem subsidy $s$ and a lump sum subsidy

$m$, respectively. There are thus two levels of revenue per unit output, where (i) $p_s \equiv p(1+s)$ denotes the unit revenue for output for exports, and (ii) $\bar{p}_d$ denotes the target price for domestic consumption.

Clearly, if $\bar{p}_d$ exceeds $p_s$, producers who remain in the industry and who produce positive output will first allocate output for sale domestically at price $\bar{p}_d$, given the base $B$. The level of any additional output to be produced is based on the maximization problem:

$$\begin{aligned} & \max_x p_s(x-B) + \bar{p}_d B - C(x) - F + m \\ = \ & \max_x p_s x + [\bar{p}_d - p_s]B - C(x) - F + m. \end{aligned} \tag{1}$$

Two observations are in order: First, infra-marginal consumer-financed subsidies are equivalent to a lump sum decoupled payment of the amount $[\bar{p}_d - p_s]B$. Second, denote $x^*(p_s)$ as the profit maximizing output level, and $e^*(p_s) = x^*(p_s) - B$ as the level of output over and above the quota $B$, it follows that the profit function can be written as:

$$\begin{aligned} & \max_e p_s e^* + \bar{p}_d B - C(e^* + B) - F + m \\ = \ & \max_e p_s e^* + \bar{p}_d B - C(x) - F + m \\ \equiv \ & \pi(p_s, m, \bar{p}_d, B) - F. \end{aligned} \tag{2}$$

Routine manipulation yields the standard price equals marginal cost condition:

$$p_s - C_x(e^* + B) \leq 0, \tag{3}$$

with complementary slackness. Specifically, the producer exports strictly positive amounts ($e^* > 0$) if and only if $p_s - C_x(B) > 0$. Equation (3) also gives the own-price supply elasticity of the individual entrepreneur as: $\epsilon \equiv C_x(x')/(C_{xx}(x')x')$. In contrast, if $p_s > \bar{p}_d$, it makes little sense for producers to allocate output specifically for sale domestically. Total output is thus given by the solution to:

$$\begin{aligned} & \max_x p_s x - C(x) - F + m \\ \equiv \ & \pi_0(p_s, m) - F, \end{aligned}$$

and $x_o(p_s)$ is given when $p_s$ meets marginal cost:

$$p_s - C_x(x_o) \leq 0, \tag{4}$$

with complementary slackness. Thus, if $\bar{p}_d \leq p_s \leq C_x(0)$, profit maximizing output is equal to zero. However, if $\bar{p}_d \leq C_x(0) < p_s$, producers maximize profits by choice of an output level that lies between 0 and base $B$. In addition, whenever $p_s \geq \bar{p}_d$, so that consumer financed subsidies are absent, net exports by the individual producer is in general indeterminate, but in the aggregate, net exports is simply given by $\widehat{N}x_o(p_s) - D(\bar{p}_d)$, where $D(\bar{p}_d)$ is defined implicitly by aggregate domestic demand evaluated at $\bar{p}_d$.

Figure 3 illustrates the case with $\bar{p}_d > p_s$. If $\bar{N}$ denotes the number of identical producers operating, total output is given by $\bar{N}x^*$, of which $\bar{N}e^* = \bar{N}(x^* - B)$ constitute exports. Note that so long as $\bar{p}_d$ is strictly greater than $p_s$, any small change in $\bar{p}_d$ in either direction will not affect total output by the individual producer $x^*$, as should be expected from equation (4) above which indicates that the true marginal revenue is just $p_s$. This is consistent with equation (1), wherein infra-marginal consumer-financed subsidies is shown to be equivalent to a lump sum payment of the amount $(\bar{p}_d - p_s)B$ so long as $\bar{p}_d$ is strictly greater than $p_s$.

Turning now to the first stage decision problem of the producer, and let $\rho$ denote the income available from the next best alternative, an individual firm is better off staying in business – defined here as the decision to incur fixed cost $F$, and the opportunity cost $\rho$, in order to be eligible to receive decoupled payment $m$ – if and only if $p_s e^* + \bar{p}_d B - C(e^* + B) - F + m \geq \rho$, or equivalently, if and only if

$$\begin{aligned} F &\leq p_s e^* + \bar{p}_d B - C(e^* + B) + m - \rho \\ F &\leq \pi(p_s, m, \bar{p}_d, B) - \rho \\ &\equiv \widehat{F}(p_s, m, \bar{p}_d, B). \end{aligned} \tag{5}$$

$\widehat{F}$ thus represents the fixed cost of the marginal entrepreneur, with total profits equal to the reservation income $\pi(p_s, m, \bar{p}_d, B) = \rho$. In other words, whenever fixed cost $F$ exceeds the threshold $\widehat{F}$, the producer would be better off ceasing production and exiting altogether. The range of producers with positive output is thus given by $[F^-, \widehat{F}]$: the larger $\widehat{F}$ is, the larger will be the range of producers who remain in the industry and produce the profit maximizing levels of output $e^* + B$. The definition of $\widehat{F}$ thus gives the number of firms with positive output levels as $\widehat{N} = N\mu(\widehat{F})$.

As with the PFC payment program in the U.S., the marginal entrepreneur who receives payment $m$ need not produce positive output levels. Indeed, if profit maximizing output is equal to zero based on equations (3) or (4) above, a farmer would still incur the fixed cost $F$ so long as $F \leq m - \rho$. Proposition 1 summarizes our observations thus far:

**Proposition 1** *A. If $F \geq \widehat{F}$, the producer exits the industry, and $x^* = e^* = 0$.*
*B. If $F < \widehat{F}$, the producer incurs the fixed cost $F$ and the opportunity cost $\rho$ to remain eligible for payment $m$. If, in addition, $\bar{p}_d \geq p_s$ and*

1. *$\bar{p}_d < C_x(0)$, then $x^* = 0$ and $e^* = 0$;*

2. *$C_x(B) > \bar{p}_d > C_x(0)$, then $x^* \leq B$ and $e^* = 0$;*

3. *$\bar{p}_d \geq C_x(B) \geq p_s$, then $x^* = B$ and $e^* = 0$;*

4. *$\bar{p}_d \geq p_s > C_x(B)$, then $x^* > B$ and $e^* > 0$.*

*C. If $F < \widehat{F}$, the producer incurs the fixed cost $F$ and the opportunity cost $\rho$ to remain eligible for payment $m$. If, in addition, $\bar{p}_d < p_s$ and*

1. *$p_s < C_x(0)$, then $x_o = 0$;*

2. *$p_s > C_x(0)$, then $x_o > 0$.*

It is in fact easy to see that whenever $\bar{p}_d > p_s$, outcomes $B1$ through 3 represent a country that is *natural* importer of the commodity in general equilibrium. Figure 3 illustrates, and takes a domestic target price $\bar{p}_d$ as given. The industry marginal cost curve evaluated at the corresponding base output $\bar{N}B$ is less than $\bar{p}_d$, but is nevertheless greater than $p_s'$, and hence by necessity the world price $p_w'$. We have thus $x^*(p_s') = B$ and $e^*(p_s', B) = 0$ since $\bar{p}_d \geq C_x(B) \geq p_s'$ for any representative producers with $F \leq \widehat{F}$. In the absence of any production subsidies, or consumer-financed payments, the country is thus a net importer of the commodity in question as domestic demand exceeds supply $\bar{N}B$. As should also be clear from the diagram, there will be a range of $p_s$, between 0 and $p_1$ in figure 3, such that small changes in coupled payments has no impact on production or exit decisions.

In what follows, we focus our analysis outcome B4 whenever producers have positive output with $\bar{p}_d > p_s$. In addition, we also focus on outcome C2 when $\bar{p}_d < p_s$, so that industry output is strictly positive. These can be thought of as an examination of direct payments in the context of exporting countries, or when $p_s$ is large enough, so that it can actually impact production and exports. To this end, we begin with equation (5), which explains the precise manner in which the size of the range of producers with positive output $[F^{-}, \widehat{F}]$ is dependent on coupled, consumer and taxpayer financed decoupled payments. In particular, if $\bar{p}_d > p_s$,

$$d\widehat{F} = dm + (x^* - B)dp_s + \bar{p}_d dB + Bd\bar{p}_d, \tag{6}$$

which follows immediately from the envelope theorem. In addition, we have from the definition of $B$ that

$$dB \quad = \quad -BN\frac{\mu'(\widehat{F})}{\mu(\widehat{F})}d\widehat{F} - \frac{d\bar{p}_d}{\eta\widehat{N}} \equiv -B\widehat{N}h(\widehat{F})d\widehat{F} - \frac{d\bar{p}_d}{\eta\widehat{N}}, \tag{7}$$

where $h(\widehat{F})$ denotes the hazard rate – the increment in the number producers with positive outputs as a share of producers with positive output $\mu(\widehat{F})$. $h(\widehat{F})$ thus measures the size of the marginal contribution of a reduction in fixed cost to aggregate output due to exits / entry.

Equations (6) and (7) can be used to solve for the exit (via $\widehat{F}$) and domestic consumption (via $B$) responses subsequent to an increase in each of the three policy measures $(m, p_s, \bar{p}_d)$ that are considered here. In particular,

$$\frac{\partial\widehat{F}}{\partial m} = \frac{1}{\Omega}; \quad \frac{\partial\widehat{F}}{\partial p_s} = \frac{x^* - B}{\Omega} > 0, \tag{8}$$

where $\Omega = 1 + (\bar{p}_d - p_s)Bh(\widehat{F}) > 0$. Thus, an increase in direct payments either coupled $p_s$ or decoupled $m$ widens the range of producers who commit to production by incurring the producer specific fixed cost $F$. Note, however, that a unit increase in $m$ increases the fixed cost of the marginal producer by strictly less than one if and only if $\bar{p}_d > p_s$ and $Bh(\widehat{F}) > 0$. The result follows since an increase in decoupled support induces entry, and reduces the share of domestic sales $B$ of each representative producer at constant target price $\bar{p}_d$. In addition,

$$\frac{\partial \widehat{F}}{\partial \bar{p}_d} = -\frac{B[\bar{p}_d(1-\eta) - p_s]}{\Omega \eta \bar{p}_d}, \tag{9}$$

which is positive if and only if the marginal revenue of an increase in sales domestically $\bar{p}_d(1-\eta)$ is no greater than the opportunity cost of devoting one more unit of output away from exports $p_s$.

Turning now to the case where the target price is *less than* the $p_s$. In this case, producers optimally allocate all of their outputs for sale at $p_s$, and we have

$$\frac{\partial \widehat{F}}{\partial m} = 1; \quad \frac{\partial \widehat{F}}{\partial p_s} = x_o; \quad \frac{\partial \widehat{F}}{\partial \bar{p}_d} = 0. \tag{10}$$

It follows that fully decoupled payments financed by taxpayers continue to increase the fixed cost of the marginal entrepreneur one to one. Meanwhile, since output is entirely allocated for sale at $p_s$, the export impact of an increase in $p_s$ is larger, as compared to the case with $\bar{p}_d > p_s$, since $x_o(p_s) \geq x_s(p_s) = x_o(p_s) - B$. Finally, so long as $\bar{p}_d < p_s$, the fixed cost of the marginal producer is unaffected by a small increase in $\bar{p}_d$.

## 3.1 Output, Export Volume and Welfare

The two-stage decision problem elaborated above allows us to define aggregate output when $\bar{p}_d > p_s$ as:

$$X^*(p_s, m, p_d, B) \equiv \widehat{N} x^*(p_s), \quad E^*(p_s, m, p_d, B) \equiv \widehat{N}(x^*(p_s) - B). \tag{11}$$

From equation (11), aggregate output depends on direct payments via two routes. First, direct payments impact the second stage decision problem of producers by distorting production incentives on the part of individual producers. To recall, the own-price output elasticity with respect to $p_s$ is given by $\epsilon > 0$. Meanwhile, since marginal costs are independent of decoupled payments, it follows from equation (3) above that

$$\frac{\partial x^*}{\partial m} = 0; \text{ and } \frac{\partial x^*}{\partial \bar{p}_d} = 0. \tag{12}$$

Thus, fully decoupled transfers as well as infra-marginal production subsidies do not affect firm level output decisions. Direct payment, whether coupled or decoupled, can however impact aggregate output by distorting the first-stage exit incentives of individual producers. Combining the marginal producer response to direct payments obtained in equation (8) above, we have

$$\frac{\partial X^*}{\partial p_s} = \widehat{N}\frac{\partial x^*}{\partial p_s} + \widehat{N}x^*(p_s)h(\widehat{F})\frac{\partial \widehat{F}}{\partial p_s} = \widehat{N}x^*(p_s)\left(\frac{\epsilon}{p_s} + \frac{h(\widehat{F})e^*(p_s,B)}{\Omega}\right) \tag{13}$$

Equation (13) implies that own-price elasticity of aggregate output $\epsilon_a$ is given by the sum of: (i) the supply elasticity of the individual producer $\epsilon$, and (ii) an exit effect which depends on the hazard rate $h(F)$, and the size of output that benefits from the production subsidy ($e^*$):

$$\epsilon_a = \epsilon + \frac{h(\widehat{F})p_s e^*(p_s,B)}{\Omega}.$$

With respect to taxpayer financed decoupled payments, we have

$$\frac{\partial X^*}{\partial m} = \widehat{N}x^*(p_s)h(\widehat{F})\frac{\partial \widehat{F}}{\partial m} = \frac{h(\widehat{F})\widehat{N}x^*(p_s)}{\Omega}, \tag{14}$$

$$\frac{\partial X^*}{\partial \bar{p}_d} = \widehat{N}x^*(p_s)h(\widehat{F})\frac{\partial \widehat{F}}{\partial \bar{p}_d} = \frac{h(\widehat{F})\widehat{N}x^*(p_s)}{\Omega}\left(\frac{B}{\eta\bar{p}_d}(p_s - \bar{p}_d(1-\eta))\right). \tag{15}$$

Thus, decoupled payments either via $m$ increases aggregate output only by its respective impact on exits, and is positive if and only if the hazard rate $h(\cdot)$ is positive. Meanwhile, infra-marginal consumer-financed subsidies via an increase in $\bar{p}_d$ widen the range of producers in the industry so long as $p_s - \bar{p}_d(1-\eta) > 0$, and $h(\cdot) > 0$.

Aggregate export consequences of direct payments can be similarly ascertained. Making use of equation (13), we have, at given target price $\bar{p}_d$, and hence domestic demand:[12]

$$\frac{\partial E^*}{\partial p_s} = \frac{\partial X^*}{\partial p_s}, \quad \frac{\partial E^*}{\partial m} = \frac{\partial X^*}{\partial m}; \tag{16}$$

and exports increase one to one as aggregate output rises with $p_s$ and $m$. In addition, if $\bar{p}_d > p_s$ and if the marginal revenue of increasing sales domestically is less than $p_s$, we have, from equation (15), that

$$\frac{\partial E^*}{\partial \bar{p}_d} = \frac{\partial X^*}{\partial \bar{p}_d} - \frac{1}{p_d'(\widehat{N}B)} > \frac{\partial X^*}{\partial \bar{p}_d} > 0. \tag{17}$$

[12]Recall that given target price $\bar{p}_d$, domestic consumption $\widehat{N}B$, is a constant with $p_d(\widehat{N}B) = \bar{p}_d$.

The profits of each representative producer thus increase with the target price $\bar{p}_d$ provided that marginal revenue of domestic consumption demand is less than $p_s$. Thus, an increase in $\bar{p}_d$ increases total exports by more than the reduction in domestic consumption due to the exit effect.

We now turn to the case where $\bar{p}_d < p_s$, wherein production decisions are independent of $\bar{p}_d$. Define aggregate production as $X_o \equiv \widehat{N}x_o(p_s)$, and net exports as $E_o \equiv \widehat{N}x_o(p_s) - D(\bar{p}_d)$, we have

$$\frac{\partial X_o}{\partial p_s} = \widehat{N}\frac{\partial x_o}{\partial p_s} + \widehat{N}x_(p_s)h(\widehat{F})\frac{\partial \widehat{F}}{\partial p_s} = \widehat{N}x_o(p_s)\left(\frac{\epsilon}{p_s} + \frac{h(\widehat{F})x_o(p_s, B)}{\Omega}\right) = \frac{\partial E_o}{\partial p_s}.$$

In addition,

$$\begin{aligned}\frac{\partial X_o}{\partial m} &= \widehat{N}x_o(p_s)h(\widehat{F})\frac{\partial \widehat{F}}{\partial m} = \frac{h(\widehat{F})\widehat{N}x_o(p_s)}{\Omega} = \frac{\partial E_o}{\partial m},\\ \frac{\partial X_o}{\partial \bar{p}_d} &= 0;\ \ \frac{\partial E_o}{\partial \bar{p}_d} = -\frac{1}{p_d'(D(\bar{p}_d))} > 0.\end{aligned}$$

Comparing these findings with equations (13) - (17), it can be readily seen that an increase in $p_s$ has a strictly larger impact on aggregate output when $\bar{p}_d < p_s$. In particular, since each unit of output is sold at $p_s$, the income increase pertaining to the marginal entrepreneur is strictly greater than when only $e^* < x^*$ units are sold at $p_s$. Decoupled payments financed by taxpayers, however, are independent of output. Hence, their impact on aggregate output are similar regardless of whenever consumer financed subsidies are in effect. Finally, since $\bar{p}_d$ no longer affect producer income whenever $\bar{p}_d < p_s$, a small change in $\bar{p}_d$ has no impact on income of the marginal entrepreneur, and hence aggregate output. Net exports increases unambiguously, however, as consumption shrinks with the higher target price $\bar{p}_d$.

Before we turn to the welfare consequences of direct payments taking into account the possibility of exits, it will be useful to compare the costs required to promote production and exports as implied by equations (14) - (17) above. Let $\phi(\in [0, 1])$ parameterize the excess burden of taxpayer financed subsidy payments (Moschini and Sckokai 1994), so that $M \equiv (1+\phi)m$ and $S \equiv (1 + \phi)(p_s - p_w)e^*(p_s)$ represent the cost of respectively financing decoupled and coupled payments for each producer.

To uncover the relative degree of distortion that decoupled and coupled payments generate, we offer two definitions: (i) a quantity-based definition with an emphasis on the aggregate output / trade impact of payments to *individual* producers, and (ii) a cost-based definition with an emphasis on the total costs required to generate a unit increase in aggregate output / exports.

**Definition 1** *Taxpayer financed decoupled payments are said to be more aggregate output (trade) distorting than coupled payments if and only if a dollar increase in decoupled payments ($M$) increases aggregate output (exports) by more than the change in output (exports) based similarly on a dollar increase in a coupled payment ($S$).*

Definition 1 is our quantity-based definition of the relative degree of distortion induced by taxpayer financed decoupled and coupled payments, since it is concerned with the amount of output / export changes induced by an increase in decoupled and coupled payments to the individual producer.[13] As such, definition 1 already encompasses the two distinct impact of direct payments: via individual output changes and exits. We have the following result:

**Proposition 2** *If $\bar{p}_d > p_s$, taxpayer financed decoupled payments are more aggregate output and trade distorting than coupled payments if and only if*

$$h(\widehat{F})(x^*(p_s - p_w) - B(\bar{p}_d - p_s)) > 1. \tag{18}$$

*If $\bar{p}_d < p_s$, taxpayer financed decoupled payments are more aggregate output and trade distorting than coupled payments if and only if*

$$h(\widehat{F})(x_o(p_s - p_w)) > 1. \tag{19}$$

**Proof:** See the Appendix.

[13] Since Definition 1 is phrased in terms of the aggregate output / export change due to an increase in payments to the individual producer, it cannot be applied to consumer financed decoupled payments since the consumer surplus loss due to an increase in the target price cannot not be readily expressed in per producer terms. Definition 2 in the sequel accommodates this observation and allows all three policies to be compared.

Thus, although taxpayer financed decoupled payments are relatively less distorting than coupled payments in terms of the output choices of individual producers ($0 = \partial x^*/\partial M < \partial x^*/\partial S$), Proposition 2 shows that decoupled payments may be nevertheless relatively more distorting in terms of aggregate output and exports so long as the exit effect of direct payments as given by the size of the hazard rate $h(\widehat{F})$ is sufficiently large. Figure 4 illustrates the intuition behind this result. In particular, an increase in coupled subsidy rate increases the producer price from $p_w$ to $p_s$, with an associated increase in subsidy expenditure (assuming here that $\phi = 0$ ) that is given by the area $a$, $b$, and $c$. Nevertheless, only area $b$ and $c$ represent the corresponding increase in producer profit. Simply put, area $c$ is dissipated as output increases from $x_1$ to $x_2$ necessitates a corresponding increase in (marginal) production cost. In contrast, an increase in decoupled payment $m$ by the amount represented by area $a$, $b$ and $c$ increases producer profit by exactly the same amount. Thus, decoupled payments can be more aggregate output and trade distorting since it has a larger impact on gross of subsidy producer profits, and hence the fixed cost of the marginal producer.

An important observation should be made here. Note that the total costs of direct payments can be written as:

$$TC = \widehat{N}(M + S) - CS, \tag{20}$$

where $CS$ denotes consumer surplus, and thus represent the amount of transfers / taxes that is required to compensate consumers for the change in consumer surplus as a result of the consumer-financed infra-marginal payments. In particular, $CS = \int_0^{\widehat{N}B} (p_d(D) - \bar{p}_d)dD$, with

$$\frac{\partial CS}{\partial \bar{p}_d} = -\widehat{N}B < 0.$$

Note from equation (20) that raising $M + S$ increases $TC$ by more than $\widehat{N}$ times the increase in direct payments $(M + S)$ to individual producers, since

$$\begin{aligned} dTC &= \widehat{N}(dM + dS) + \widehat{N}h(\widehat{F})(M + S)[\frac{\partial \widehat{F}}{\partial M}dM + \frac{\partial \widehat{F}}{\partial S}dS + \frac{\partial \widehat{F}}{\partial \bar{p}_d}d\bar{p}_d] - \widehat{N}Bd\bar{p}_d \\ &\geq \widehat{N}(dM + dS) - \widehat{N}Bd\bar{p}_d, \end{aligned} \tag{21}$$

where the three terms in square brackets follows from the effect of direct payments on the actual number of producers receiving payments. As such, the total cost of decoupled (taxpayer

/ consumer financed) and coupled payments should not be considered as separate entities, since raising decoupled payments to individual producers can in fact increase the costs of coupled payments, whenever the number of producers receiving coupled payments also increase with $M$. This observation prompts us to define:

**Definition 2** *Decoupled payments, whether taxpayer or consumer financed, are said to be more aggregate output (trade) distorting than coupled payments if and only if the total costs increase required to generate a unit increase in aggregate output (exports) via decoupled payments is strictly less than the total cost increase required to generate a unit increase in aggregate output (exports) through coupled payments.*

Making use of Definition 2, we have the following result:

**Proposition 3** *If $\bar{p}_d > p_s$, taxpayer financed decoupled payments are more aggregate output and trade distorting than coupled payments according to Definition 2 if and only if*

$$h(\widehat{F})(x^*(p_s - p_w) - B(\bar{p}_d - p_s) - e^*(p_s - p_w) - m) > 1. \tag{22}$$

*If $\bar{p}_d \leq p_s$, coupled payments are always more aggregate output and trade distorting than taxpayer financed decoupled payments.*

**Proof:** See the Appendix.

Two points deserve particular attention. To begin with, the relative effectiveness of an increase in $m$ in discouraging exit as shown in proposition 2, simply translates to a larger increase in the total cost of direct payments $\widehat{N}(M + S)$ through the number of firms eligible for payments $\widehat{N}$, relative to when coupled payments $S$ are deployed. It follows, therefore, that in the absence of consumer financed subsidies, coupled payments – with the additional ability to distort marginal production decisions – are the most (total) cost effective means of distorting aggregate output. This gives the second part of Proposition 2. In contrast, in the presence of infra-marginal consumer financed subsidies, raising $p_s$ has two distinct effects: (i) it replaces the share of producer profits that is effectively paid for via consumer financed infra-marginal subsidy ($B(\bar{p}_d - p_s)$) with coupled subsidies, and (ii) it distorts producers' marginal production decision, as $(x^* - B)(p_s - p_w) = e^*(p_s - p_w)$ represents the increase in producer profits due to coupled payments. Thus, every dollar increase in the total cost of direct payments via coupled subsidy is used partly to shift the composition of the producer profit increase due to (consumer financed infra-marginal versus coupled) government subsidies, and only partly to influence output. The first part of this proposition thus reflects this observation, and shows in particular that even when the total cost of direct payments are accounted for, taxpayer financed decoupled payments can still be more aggregate output and trade distorting relative to coupled payments.

The difference between Propositions 2 and 3, based respectively on the quantity-based and cost-based definitions of the relative distortions generated by coupled and decoupled payments are of clear policy significance. In particular, it shows that the way in which payment definitions are made in trade rules can make a significant difference as to whether "green box" policies can be expected to generate a smaller toll on trade flows than fully coupled policies. Whether the role of exit can be large enough to overturn standard prediction is of course an empirical issue, which has to do with the size of the hazard rate. A more detailed explanation of this is offered in section 4.

Perhaps more importantly, note that the left hand side of equations (18) and (19) under Proposition 2 are both dependent on the existing loan rate $p_s$. The same is true of equation (22) under Proposition 3. In particular, the higher the loan rate, the higher the left hand side expressions of these three equations become at given $h(\widehat{F})$, and as such, the more likely that decoupled payments can be more trade distorting. In this light, for countries with different levels of existing production subsidies, the likely impact of a regime switch to decoupled payments can be diametrically opposite.

In a similar spirit to definition 2, we can also refer to consumer financed infra-marginal subsidies as more output / trade distorting than taxpayer financed decoupled (coupled) payments if and only if the total costs (which includes any consumer surplus losses) increase required to generate a unit increase in aggregate output (export) via the target price $\bar{p}_d$ is strictly less than the total cost increase required to generate a unit increase in aggregate output (exports) through taxpayer financed decoupled (coupled) payments. To this end, we have the following result:

**Proposition 4** *If* $\bar{p}_d > p_s$*,*

1. *Infra-marginal consumer financed payments are more aggregate output distorting than taxpayer financed decoupled payments according to Definition 2 if and only if*

$$1 + \phi \geq \frac{\bar{p}_d \eta}{p_s - \bar{p}_d(1 - \eta)}. \tag{23}$$

   *Under the same sufficient condition (equation 23), infra-marginal consumer financed payments are also more trade distorting than taxpayer financed decoupled payments according to Definition 2.*

2. *Infra-marginal consumer financed payments are more aggregate output distorting than coupled payments according to Definition 2 if equations (22) and (23) are satisfied. Under the same set of sufficient conditions (equations 23 and 24), infra-marginal consumer financed payments are also more trade distorting than coupled payments according to Definition 2.*

**Proof:** See the Appendix.

Part 1 of Proposition 4 follows from the results elaborated in section 3.1, that taxpayer financed decoupled support and consumer-financed subsidies both affect aggregate output only through their impact on exits. It follows that if the increase in producer profits via an increase in $\bar{p}_d$ is sufficiently high, which follows whenever marginal revenue $p_s - \bar{p}_d(1 - \eta)$ is sufficiently small, infra-marginal consumer-financed subsidies can be more output distorting than taxpayer financed decoupled payments. As a special case, however, let $\phi = 0$, so that there is no excess burden associated with decoupled payments, it can be readily verified that the inequality in equation (23) above can never be satisfied, so long as $\bar{p}_d > p_s$. Naturally, when taxpayer financed decoupled payments do not incur dead weight losses, it is always relatively more output distorting than consumer-financed payments according to definition 2.

### 3.2 Welfare Consequences of Direct Payments

Taking into account the exit and output effects of direct payments, we now turn to welfare. Specifically, let $W$ denote the sum of income of the $N$ producers plus consumer surplus, net of the costs of subsidies:

$$W(p_s, m, \bar{p}_d) = N \int_{F^-}^{\widehat{F}} (\pi(p_s, m, \bar{p}_d, B) - F) d\mu(F) + N \int_{\widehat{F}}^{F^+} \rho d\mu(F) - TC + CS$$

Making use of equations (13) - (15), we have

$$\frac{\partial W}{\partial m} = -\widehat{N}(1 + \frac{h(\widehat{F})(M+S)}{\Omega})\phi + \widehat{N}h(\widehat{F})\left([\pi(p_s, m, \bar{p}_d, B) - \widehat{F} - \rho] - M - S\right)\frac{1}{\Omega}$$

where the first term on the right hand side of the above expression is negative whenever the excess burden ($\phi$) of financing direct payments is greater than zero. The second term in square bracket depicts the increase in producer income when the marginal producer switches to production by forgoing the next best alternative. But then from equation (5), production profits and the income available from the next best alternative are exactly equal for the marginal producer. The welfare effect of $m$ above thus illustrates exactly how direct payments deter exit by effectively *covering* operating costs. In particular, the expression above can be simplified to obtain

$$\frac{\partial W}{\partial m} = -\widehat{N}\left(1 + \frac{h(\widehat{F})(M+S)}{\Omega}\right)\phi - \widehat{N}h(\widehat{F})(M+S)\frac{1}{\Omega} < 0$$

Thus, since producers with relatively large fixed costs would have exited the industry, and negative (net of subsidy) profits would have otherwise not been incurred, the entire amount of firm-level gross of subsidy profit increase that are paid for via government direct payments $\widehat{N}h(\widehat{F})(M+S)\frac{1}{\Omega}$ in fact contribute to a further increase in the deadweight loss of direct payments.

Similarly, we have

$$\frac{\partial W}{\partial p_s} = -\widehat{N}\left(e^* + h(\widehat{F})\frac{M+S}{\Omega}\right)\phi - \widehat{N}h(\widehat{F})(M+S)\frac{1}{\Omega} - \widehat{N}(1+\phi)\frac{p_s - p_w}{p_s}x^*\epsilon < 0$$

$$\frac{\partial W}{\partial \bar{p}_d} = -\frac{\widehat{N}B}{\eta} + \widehat{N}Bh(\widehat{F})\left(\frac{\bar{p}_d(1-\eta) - p_s}{\eta\bar{p}_d}\right)(\bar{p}_d B + M + S) < 0$$

where the last inequality follows if marginal revenue of domestic consumption demand $\bar{p}_d(1-\eta)$ is less than $p_s$. These observations give:

**Proposition 5** *For any $\phi \geq 0$, an increase in either coupled $(S)$ or taxpayer financed decoupled payments $(M)$ strictly decreases aggregate welfare $(W)$. In addition, the consumer surplus and government revenue losses due to an increase in the target price $\bar{p}_d$ always exceeds the gain in total producer surplus.*

In sum, Propositions (2) - (4) are of particular importance when evaluating the choice between coupled, taxpayer financed decoupled, and consumer financed infra-marginal production subsidy payments. In particular, if the objective is to maximize exports, a shift in favor of taxpayer financed decoupled payments may in fact increase production, and distort trade flows even more, provided that the exit effect as parameterized by the hazard rate is large enough.

Meanwhile, if the objective is to raise producer surplus while minimizing costs, the question that should arise is the extent to which accounting for the exit deterrence effects of production subsidy alter the size of the deadweight loss associated with direct payments. Here again, the relevant question to be ascertained empirically is whether the size of the hazard rate is significant enough to overturn standard results in the context of short run analysis in the absence of exits. In what follows, we turn to an examination of the calibration framework, and in particular, how the size of the exit deterrence effect can be calibrated.

# 4 Calibration

In this section, we discuss specific functional forms for production technologies, and the distribution of fixed cost that are used in the calibration to follow. Since the benchmark data that we use pertains to wheat production in the U.S. for 1998, our calibration exercise focuses on the output, trade and welfare effects of coupled and taxpayer financed decoupled payments, and consumer surplus is taken as given and evaluated at the prevailing world price. More specifically, let fixed cost $F$ be a normally distributed random variable, with mean $\bar{F}$, and variance $\sigma^2$. In addition, let

$$G(L_x) = L_x^{\alpha}.$$

Taking as given any observed output level $\bar{x}$ by the representative producer at given $\bar{p}_s$, the profit maximizing output level for any other $p_s$ is given simply by

$$x(p_s, \bar{x}, \bar{p}_s, \alpha) = \bar{x} \left( \frac{\bar{p}_s}{p_s} \right)^{\alpha/(\alpha-1)}. \tag{24}$$

This implies that total profits per producer is given by:

$$\pi(p_s, m, \bar{x}, \bar{p}_s, \alpha) - F = (1-\alpha) p_s \bar{x} \left( \frac{\bar{p}_s}{p_s} \right)^{\alpha/(\alpha-1)} + m - F. \tag{25}$$

For lack of an obvious choice for the reservation income of the representative producer, we take $\rho = 0$ as a minimal benchmark for the range of producers who are exposed to possibility of exits. It follows that from equation (5) that the marginal producer has fixed cost

$$\widehat{F}(p_s, m, \bar{x}, \bar{p}_s, \alpha) = \pi(p_s, \bar{x}, \bar{p}_s, m) \tag{26}$$

and the number of producers with $F \geq \widehat{F}$ is given by $\widehat{N}(p_s, m, \bar{x}, \bar{p}_s, \alpha, \bar{F}, \sigma^2) = N\mu(\widehat{F}; \bar{F}, \sigma^2)$, where $\mu(\cdot)$ denotes the cumulative distribution function of a normal distribution with mean $\bar{F}$ and variance $\sigma^2$.

To evaluate aggregate output and export consequences of direct payments, note that total output is given by

$$\begin{aligned} X^*(p_s, m, \bar{x}, \bar{p}_s, \alpha, \bar{F}, \sigma^2) &= \widehat{N}(p_s, m, \bar{x}, \bar{p}_s, \alpha, \bar{F}, \sigma^2) x(p_s, \bar{x}, \bar{p}_s) \\ &= N\mu(\widehat{F}(p_s, m, \bar{x}, \bar{p}_s, \alpha); \bar{F}, \sigma^2) \bar{x} \left( \frac{\bar{p}_s}{p_s} \right)^{\alpha/(\alpha-1)}. \end{aligned} \tag{27}$$

Total exports is thus $X^*(p_s, m, \bar{x}, \bar{p}_s, \alpha, \bar{F}, \sigma^2) - D$, where $D$ denotes total domestic consumption in 1998.

In addition, since $F$, and thus the profit of any one of the $N$ producers, is normally distributed, the mean profit of producers conditional on profits being positive is

$$\Pi(p_s, m, \bar{x}, \bar{p}_s, \alpha, \bar{F}, \sigma^2) = \int_0^\infty ad \left( \frac{\mu(a; \pi(p_s, m, \bar{x}, \bar{p}_s, \alpha) - \bar{F}, \sigma^2)}{1 - \mu(0; \pi(p_s, m, \bar{x}, \bar{p}_s, \alpha) - \bar{F}, \sigma^2)} \right) \tag{28}$$

since $\pi(p_s, m, \bar{x}, \bar{p}_s, \alpha) - \bar{F}$ and $\sigma^2$ are respectively the expectation and the variance of individual producer profits.[14] Finally, the total cost to finance the two types of direct payments is given

[14] Numerical values of $\Pi(\cdot)$ can be readily obtained using Maple V (Release 3).

by:

$$TC(p_s, m, \bar{x}, \bar{p}_s, \alpha, \bar{F}, \sigma^2) = \widehat{N}(p_s, m, \bar{x}, \bar{p}_s, \alpha, \bar{F}, \sigma^2)(1+\phi)(m + (p_s - p_w)x(p_s, \bar{x}, \bar{p}_s, \alpha)). \quad (29)$$

These observations lay the foundation for the calibration results summarized in tables 5 to 7, where the output, export and producer welfare consequences of U.S. wheat policy in 1998 are examined. In particular, equations (25) - (30) require that the following parameters be identified for computation purposes: (i) $(\bar{x}, \bar{p}_s)$ – a status quo per producer output level and the corresponding loan rate; (ii) $\alpha$ – the variable cost share parameter, and (iii) $(\bar{F}, \sigma^2)$ the mean and the variance of the fixed cost distribution. We have data on aggregate wheat production in 1998 (2,546.46 million bushels), total acreage (65.8 million acres), yield (35.8 bushels per acre), along with the number of farms operating (43739). These are summarized in Tables 2 and 3, and give the average production per farm $\bar{x}$ at 0.0582 million bushels.

From Table 3, total LDP payments in 1998 was at \$476.5 million. The loan rate $\bar{p}_s$ applied during the same year is at \$2.58 per bushel. These imply that $\bar{p}_s - \bar{p}_w$ is equal to \$0.19 per bushel in 1998, and the implied market price of wheat $\bar{p}_w$ is thus \$2.39 per bushel.

Table 2 also list production costs information. The variable cost share parameter $\alpha$ is given by total variable cost (\$53,154) as a share of total revenue at \$2.58 per bushel.[15] This implies a variable cost to revenue share that is equal to 0.35. The implied own-price elasticity of supply on the level of individual producers is equal to 0.52.

Finally, with respect to cost distribution parameters, we make use of the coefficient of variation of fixed cost distribution (3.48) available from Ali, Brooks and McElroy (2000). The standard deviation ($\sigma$) of the distribution of fixed costs is thus equal to \$74423.28, given the mean fixed cost $\bar{F}$ in Table 2 is \$21,386.[16] This completes the description of our calibration framework and data. We now turn to the results of our calibration.

[15] Variable costs include seed, fertilizer, chemicals, custom operations, fuel and electricity, repairs, purchased irrigation water, and interest on operating inputs (Farm Business Income Statement for Wheat Farms, 1996 - 1999).

[16] Fixed cost is the sum of real estate and property taxes, interest, insurance premiums, rent and lease payments and other general farm overheads (Farm Business Income Statement for Wheat Farms, 1996 - 1999).

## 5 Calibration Results

We begin by examining the standard short run analysis wherein the number of farms stays constant at 43,739 in Table 5A, taking as given the first column, which summarizes the 1998 status quo level (loan rate was \$2.58, and PFC payments amounted to \$10,083 per farm) of aggregate and farm level output, along with exports. In the absence of infra-marginal consumer financed subsidies, total consumption will be taken as the 1998 level (1505.6 mill. bushels) throughout.

Since the total number of farms is assumed to be constant in this first case, the second column of Table 5A shows that removing PFC payments, while keeping the loan rate at \$2.58 has no effect on production relative to the 1998 status quo, and as such it has no effect on exports. However, removing LDP while keeping PFC payments at an average level of \$10,083 per farm lowers output and exports by 104.48 million bushels in the aggregate, and 0.0024 million bushels in the farm level – a average of 4.1% reduction relative to the 1998 benchmark. This reduction remains the same even when PFC payments are removed in addition to the removal of LDPs, as PFC payments does not distort production here.

The next two rows of Table 5A summarize our findings on whether coupled or decoupled payments are relatively more output (and hence trade) distorting based on Definitions 1 and 2. In particular, starting from the 1998 status quo, removing PFC payments has no impact on exports. If LDP payments are removed instead, aggregate export revenue (evaluated at \$2.39) decreases by \$0.02257 (\$0.0209) million for each dollar saved on coupled payments to individual farmers at zero % (8%) excess burden. As may be expected, therefore, the effectiveness of direct payments in affecting exports is the highest with LDPs based on Definition 1 when the possibility of exit is ignored.

The last two rows of Table 5A show that LDPs continue to be the relatively more trade distorting policy measure based on Definition 2. Starting once again from the status quo in 1998, the removal LDP payments implies a direct payment cost savings of \$1.94 (\$2.09), for every dollar worth of export revenue forgone at zero % (8%) excess burden. However, no increase in PFC payments can ever raise aggregate export. In essence, these observations simply highlight the lack of output response to PFC payments in the absence of exits.

Note that since fixed costs, and hence the variable profit net of fixed cost, are assumed to be normally distributed, the implied hazard rate can be readily computed and is plotted in Figures 5 (a) and (b). As may be expected, the normal distribution has a monotone hazard rate, which is strictly decreasing in the fixed cost of the marginal producer. In addition, changes in the standard deviation and the mean of the fixed cost (and total profits) distribution, shifts the hazard rate in the sense that the higher the variance, and the lower the mean fixed cost, the lower will be the hazard rate at each level of fixed cost. Similar parametric changes in the fixed cost distribution can thus be expected to play a key role in the way in which Propositions 2 and 3 apply in our calibration exercise.

Table 5B accordingly considers the possibility of exits.[17] Conditional on positive gross of subsidy profits, the number of farms reduces to 38,288 even when both PFC and LDP payments remain in place (a 12.46% reduction relative to the actual 1998 level). This implies that whereas output per farm remains at the 0.0582 million bushels, total production and exports drop respectively to 2229.11 and 723.51 million bushels. Removing PFC payments entirely leads to an additional 3% of the 43,739 representative farms to exit the industry, and aggregate production and export fall further respectively to 2,152.65 and 647.05 million bushels. This is in contrast to Table 5A, wherein the removal of PFC payments has no impact on aggregate production and exports. Note that the implied own-price aggregate supply elasticity is 1.14, more than twice the value predicted when the possibility of exit is not accounted for.

[17] Of course, there are many other conceivable frictions that can enter into the exit decisions of farmers. These may include: (i) transaction costs and imperfect occupation mobility; (ii) expectations that future subsidies will be forthcoming (or higher market prices) in a more explicitly dynamic setting; (iii) expectations that other support programs, or cost-reducing technological changes may emerge; (iv) possibility of multiple crops or crop switching rather than exit; (v) agricultural lease arrangements that were already in place prior to 1996 and remain unchanged after (Bierlen et al. 2000); (vi) strategic response to direct support as landowners anticipate the possibility of raising land rents (Schertz and Johnson 1997), and manipulate contract terms to encourage farm operators to continue farming. All of these constitute some additional reasons why exit incentives may be deterred. In this study, our results should accordingly be interpreted as the change in the vulnerability of farmers to exit due only to direct payments, conditional on these plausible external factors.

If LDP is removed at market price \$2.39, but PFC payments are intact, aggregate output and exports fall to even further respectively to 2058.42 and 552.82 million bushels. These numbers are lower compared to both the case of Table 5A wherein the possibility of exits are not accounted for, as well as the second column of Table 5B, wherein only PFC payments are removed. Finally, the last column of Table 5B reports the output and export impact of direct payments when both LDP and PFC payments are removed. The result is a 19.18% reduction of total output relative to the 1998 observed status quo. Total exports also fall, but remain positive at 467.88 million bushels.

We now turn to an examination of the relative production distortion generated by coupled and decoupled payments. At respectively zero and 8% excess burden of taxpayer financed direct payments, the removal of PFC payments implies a corresponding reduction in export revenue by \$0.01812 and \$0.01678 million per dollar saved in payment per farm. Meanwhile, the removal of LDP payments imply twice as large a reduction in export revenue (\$0.03688 and \$0.03415 million) per dollar saved in payment per farm. It follows from Definition 1 that coupled payments are more trade distorting even after the possibility of exits is accounted for. With respect to Definition 2, our findings are also in concert with the predictions in Proposition 3. Specifically, coupled payments are more trade distorting than decoupled payments, in the sense that the savings in total direct payment per dollar export revenue forgone is strictly higher when decoupled (at \$2.19 and \$2.37), rather than coupled subsidies (at \$1.07 and \$1.15) are removed.

Table 6A and Table 7A summarize the profits and dead weight loss implications of direct payments both in the farm level and in the aggregate without exits. What may be of particular interest is the change in farm profits per dollar saved in direct payments. In particular, starting from the 1998 status quo, aggregate farm profits decreases one to one with decoupled PFC payments at zero % excess burden in Table 6A. Meanwhile, farm profits decreases by strictly less than the savings in coupled LDP payments (\$0.9796). The intuition follows from our discussion in section 3, wherein LDPs are shown to generate a production dead weight loss, as producers are induced to operate at higher marginal costs, in order to gain access to subsidy payments.Thus, PFC payments are the most cost-effective means of raising farm profits. This is also in concert with the observation in Table 7A the dead weight loss associated with LDP payments is the highest (at 10.04% of total payments at 8 % excess burden), compared to PFC payments alone (at 8%).

The picture changes considerably when the possibility of exit is accounted for in Tables 6B and 7B. Recall from Section 3 that direct payments in effect *cover* the negative profits that individual farms would not otherwise experience as the exit option opens up, the dead weight loss associated with direct payments in the long run can be considerably higher. As is evident in Table 6B, the reduction in profits associated with a dollar reduction in government budget is lower in all three cases, although the ranking between the profit impact of removing LDP and PFC payments remain the same as in Table 6A. Respectively, a $0.95 and $0.93 decrease in profits can be expected to be associated with a dollar reduction in aggregate spending on PFCs and LDPs. As a fraction of total payments, however, these numbers are considerable, in particular, closed to 40% of direct payments are used to *cover* costs, and hence, should be accounted for as part of the dead weight loss associated with direct payments, as in Proposition 5.

## 5.1 Sensitivity

A natural question that arises, given the results above, is under what conditions should one expect the relative importance of PFC and LDP payments to switch places. In particular, we are interested in examining various parameter configurations, such as the distribution of fixed costs, the elasticity of supply based on variable cost share, that may imply that our results may vary. In Figures 6(a) and (b), we conduct such an analysis by plotting the value of the left hand side of equation (18) in Proposition 2 under various distributional and technological assumptions. In particular, the left hand side of equation (18) is strictly negative under the 1998 status quo, which of course implies the findings in our simulation exercise. However, as (i) the variance of the distribution decreases, (ii) the mean fixed cost rises, and (iii) the farm level own-price supply elasticity increases, Figure 6(b) shows that there decoupled payments can indeed be more output/ trade distorting than coupled payments in the sense of Definition 1.

Note that in both figures, whether or not decoupled payments are more trade and output distorting depends critically on the existing loan rate and decoupled payment. Given a lower standard deviation, a higher mean fixed cost and a higher elasticity of supply than the 1998 status quo, countries with (i) existing loan rates that are higher than, and (ii) existing decoupled payments that are lower than the 1998 level in the U.S., a switch in direct payment expenditures in favor of decoupled support is likely to be more trade distorting. A clear implication of these findings is therefore that wholesale application of decoupled in favor of coupled support should be treated with caution. Indeed, not only does the underlying cost-distributional and technological parameters matter, the level of existing support would seem to be equally important.

# 6 Conclusion

This paper proposes an analytical framework based on the premise that fixed costs and the decision to exit impact aggregate production, and hence export consequences of direct income payments. In particular, even though decoupled payments do not affect production decisions at the margin (Collins and Vertrees 1988), the exit deterrence effect of decoupled payments can potentially be more output distorting than coupled payments, once the deadweight losses associated with coupled payments are taken into account (section 3.1). Meanwhile, to the extent that aggregate output depends on the decision to exit, direct income payment can cross-subsidize exports, and distort international trade flows depending on the distribution of fixed costs across individual farm units. Attempts to evaluate the relative merits of decoupled and coupled payments based on their impact on aggregate trade flows and producer welfare should accordingly take into account the impact that both marginal and infra-marginal payments may have on aggregate output, and export levels.

In this exploratory study, we take wheat production in the U.S. as a case in point. The calibration framework laid out in section 3.2 is employed to study the output and export consequences of three policy scenarios, having to do with the removal of LDP payments, PFC payments, and both. The results are broadly consistent with our analytical findings, in that whereas removal of decoupled payments can have a relatively large impact on the exit decision on low-profit farm units, its aggregate output impact can remain quite limited so long as the output level of the marginal farm is relatively small. Clearly, these results are sensitive to the distribution of PFC payments across farm size, along with the reservation profit of the marginal farm.[18]

Thus, if reductions in decoupled payments are biased in such a way as to disproportionately favor low output farms, the exit deterrence consequence of direct income payments may imply a much smaller output and export distortion than suggested in this study. Meanwhile, if existing income payments generates expectation of future payments that compensates short-term losses, the reservation profit of the marginal farm may take on a negative value and the aggregate output and export distortion of decoupled payments can accordingly be considerably larger. Also of interest seems to be the possibility of the interaction between risk-induced production distortion, and the way in which direct income payment impacts producers' attitudes towards risk. The resulting output and export distortion should therefore appropriately account for: (I) direct payments as a corrective policy in the face of risk aversion (Bhagwati 1971); (II) the risk aversion impact of direct payment in the presence of non-constant rate of risk aversion (Hennessy 1998) and (III) the risk exposure effect of infra-marginal consumer financed export subsidies when barriers to trade also provide an income safety net for agricultural producers. Much more work clearly remains to be done in this area.

## Appendix

**Proof of Proposition 2:** Since $M = (1+\phi)m$ and $S = (1+\phi)(p_s - p_s)e^*$, we have

$$\frac{\partial m}{\partial M} = \frac{1}{(1+\phi)} \tag{30}$$

$$\frac{\partial p_s}{\partial S} = \frac{1}{(1+\phi)[e^* + (p_s - p_w)x^*\epsilon/p_s]}. \tag{31}$$

[18]There is overwhelming evidence that large farms receive a disproportionate share of government payments. Meanwhile, government payments per unit output is decreasing with the farm size(see Kuhn and Offutt 1999, and ABARE 2001).

Thus, making use of equations (29) - (30), routine manipulation yields

$$\frac{\partial X^*}{\partial M} - \frac{\partial X^*}{\partial S} = \frac{\partial X^*}{\partial m}\frac{\partial m}{\partial M} - \frac{\partial X^*}{\partial p_s}\frac{\partial p_s}{\partial S} > 0$$

if and only if equation (18) is satisfied. Equation (19) is obtained by substituting $e^* = x^*$ and $B = 0$ into equation (18) as producers optimally devote their entire output for sale at price $p_s$.

**Proof of Proposition 3:** Equations (29) and (30) can be used jointly with equation (19) to obtain

$$\begin{aligned}\frac{\partial TC}{\partial M} &= \widehat{N} + \widehat{N}h(M+S)\frac{\partial \widehat{F}}{\partial m}\frac{\partial m}{\partial M} \\ \frac{\partial TC}{\partial S} &= \widehat{N} + \widehat{N}h(M+S)\frac{\partial \widehat{F}}{\partial p_s}\frac{\partial p_s}{\partial S}\end{aligned}$$

Substituting equation (8) into (31) and (32) above yields the two conditions stated in the text, which guarantees that

$$\frac{\partial TC}{\partial M}\frac{\partial M}{\partial X} - \frac{\partial TC}{\partial S}\frac{\partial S}{\partial X} > 0$$

evaluated respectively at $\bar{p}_d > p_s$ and $\bar{p}_d < p_s$.

**Proof of Proposition 4:** By definition of consumer surplus, we have

$$\frac{\partial CS}{\partial \bar{p}_d} = -\widehat{N}B$$

we have,

$$\frac{\partial (TC - CS)}{\partial \bar{p}_d} = \widehat{N}B + \widehat{N}h(M+S)\frac{\partial \widehat{F}}{\partial \bar{p}_d}$$

Equation (33) can be used jointly with equation (13) in the text to obtain the equations (21) and (22) in the text which guarantee respectively that

$$\frac{\partial (TC - CS)}{\partial \bar{p}_d}\frac{\partial \bar{p}_d}{\partial X} - \frac{\partial TC}{\partial M}\frac{\partial M}{\partial X} < 0$$

and

$$\frac{\partial (TC - CS)}{\partial \bar{p}_d}\frac{\partial \bar{p}_d}{\partial X} - \frac{\partial TC}{\partial S}\frac{\partial S}{\partial X} < 0.$$

Finally, note that since domestic consumption $\widehat{N}B$ is by definition independent of $M$ and $S$, but is strictly decreasing in $\bar{p}_d$, it follows immediately that if the sufficient conditions for infra-marginal consumer financed payments to be relatively more output distorting that both taxpayer financed decoupled payments and fully coupled payments, it must by necessity be also more trade distorting relative to the same two types of direct payments.

## References

ABARE (Australian Bureau of Agricultural and Resource Economics), 2001. "US and EU Agricultural Support: Who does it benefit?" *Current Issues* number 2, October. http://www.affa.gov.au/corporatedocs/publications/pdf/marketaccess/CI002.pdf

Ali, M. B., N.L. Brooks and R. G. McElroy, 2000. *Characteristics of U.S. Wheat Farming: A Snapshot.* Statistical Bulletin No. 986. Economic Research Service, U.S. Department of Agriculture, June.

Annad, M., D. Buckingham and W. Kerr, 2001. *Export Subsidies and the World Trade Organization.* Estey Centre Research Papers, Number 1, Estey Centre for Law and Economics in International Trade, Saskatoon, Saskatchewan.

Bierlen, R., L. D. Parsch, and B. L. Dixon and B. L. Ahrendsen (2000). "The 1996 FAIR Act: Measuring the Impacts on Land Leases." *Review of Agricultural Economics*, 22 (2): 336-354

Bhagwati, J. N., 1971. "The Generalized Theory of Distortions and Welfare", in J.N. Bhagwati, R. W. Jones, R. Mundell and J. Vanek (eds.) *Trade, Balance of Payments and Growth: Papers in International Economics in Honor of Charles P. Kindleberger* (North Holland: Amsterdam).

Blandford, D., 2000. "Are Disciplines Required on Domestic Support?" Paper Presented at the Canadian Agri-Food Trade Research Network Workshop on *Agricultural Trade Liberation: Can We Make Progress?* Quebec City, Quebec, October 27-28.

Borges, R., and W. Thurman, 1994. "Marketing Quotas and Random Yields: Marginal Effects of Inframarginal Subsidies on Peanut Supply". *American Journal of Agricultural Economics* v76, n4 (November):809-17.

Brink, L., 2000. "Domestic Support Issues in the Uruguay Round and Beyond" Trade Research Series, Agriculture and Agri-Food Canada, July. Ottawa, Canada.

Cahill, S., 1997. "Calculating the Rate of Decoupling for Drops Under CAP/Oilseeds Reform" *Journal of Agricultural Economics*, 48(3), 349-78.

Collins, K. and J. Vertrees, 1988. "Decoupling and U.S. Farm Policy Reform," *Canadian Journal of Agricultural Economics* 36: 733-745.

Gardner, B., 2000. "The Agricultural Negotiations: An Overflowing Agenda" *Federal Reserve Bank of St. Louis Review* v82, n4 (July-Aug.): 73-75.

Gisser, M. 1993. "Price Support, Acreage Controls and Efficient Redistribution" *Journal of Political Economy* V. 101, n4 (August), 584-611.

Hennessy, D. A. 1998. "The Production Effects of Agricultural Income Support Policies under Uncertainty," *American Journal of Agricultural Economics* 80: 46-57.

Kuhn, B. and S. Offutt, 1999. "Farm Policy in an Era of Farm Diversity", *Choices* 14(3), 37.

Moschini, G. and P. Sckokai. 1994. "Efficiency of Decoupled Farm Programs Under Distortionary Taxation," *American Journal of Agricultural Economics* 76: 362-370.

OECD, 2000. "Decoupling: A conceptual overview" COM/AGR/APM/TD/WP(2000)14. Paris, France.
http://www.oecd.org/agr/Documents/wp0014fe.pdf

OECD, 2001. "Agricultural Policies in OECD Countries: Monitoring and Evaluation 2001." Paris, France.

Roberts, I., 1997. "Australia and the Next Multilateral Trade Negotiations for Agriculture." ABARE Research Report 97.6, Canberra.

Rucker, R., W. Thurman and D. Sumner, 1995. "Restricting the Market rfor Quota: An Analyss of Tobacco Production Rights with Corroboration from Congressional Testimony". *Journal of Political Economy* v103, n1 (February): 142-75.

Rucker, R. and W. Thurman, 1990. "The Economic Effects of Supply Controls: The Simple Analytics of the U.S. Peanut Program" *Journal of Law and Economics* v33, n2 (October): 483-515.

Schertz, L. and W. Johnson, 1997. "Managing Farm Resources in the Era of the 1996 Farm Act." ERS Staff Paper No. 9711, USDA, Washington, D. C., December.

Schluep, I. And H. de Gorter, 2001. "The Definition of Export Subsidies and the Agreement on Agriculture," in G. Peters (ed.) *Tomorrow's Agriculture: Incentives, Institutions, Infrastructure and Innovations*, Oxford University Press, forthcoming.

Schmitz, A. and J. Vercammen, 1995. "Efficiency of Farm Programs and their Trade-Distorting Effect" in G. Rausser (ed.), *GATT Negotiations and the Political Economy of Policy Reform*, pp. 35-36.

Skees, J. R. 1999. "Agricultural Risk Management or Income Enhancement?" *Regulation*, 22(1): 35-43.

Sumner, D. and C. Wolf, 1996. "Quotas without Supply Control: Effects of Dairy Quota Policy in California" *American Journal of Agricultural Economics* v78, n2 (May): 354-66.

United States Department of Agriculture – Economic Research Service, 2001. "Wheat Situation and Outlook Yearbook." WHS-2001, March.

**Table 1: Direct Government Payments (all major field crops in mil. $)**

| | 1997 | 1998 | 1999 | 2000F | 2001F |
|---|---|---|---|---|---|
| **Total direct payments** | 8,070 | 12,213 | 20,594 | 22,125 | 14,123 |
| Production Flexibility (PFC) | 6,120 | 6,001 | 5,046 | 4,851 | 4,046 |
| Loan Deficiency (LDP) | na | 1,792 | 5,895 | 6,400 | 4,500 |
| CRP and Other | 1,950 | 1,579 | 1,849 | 2,004 | 1,945 |
| Emergency Assistance | 0 | 2,841 | 7,804 | 8,870 | 3,632 |

F = forecast, na = not applicable

Source: USDA-ERS, www.ers.usda.gov/Briefing/FarmIncome/fore.htm

**Table 2: Fixed *versus* Variable Costs and Government Payments for Wheat**

| 1998 | All wheat farms |
|---|---|
| # of farms | 43,739 |
| Gross Cash Income | 91,770 |
| Government Payments | 19,522 |
| Average PFC Payment | 10,083 |
| Average LDP Payment | 4,111 |
| Less: Cash Expenses | 74,540 |
| Variable | 53,154 |
| Fixed | 21,386 |
| Equals: Net Cash Farm Income | 17,230 |
| Net Farm Income | 15,752 |

**Source:** United States Department of Agriculture, Economic Research Service, Agricultural resource Management Survey (ARMS) data, Mitch Morehart. http://www.ers.usda.gov/data/arms

**Table 3: U.S. Wheat Market and Policy Data**

| | 1998 |
|---|---|
| LDP payment (mil. $) | 476.5 |
| Loan Rate | 2.58 |
| Base Acres (Mil. acres) | 78.9 |
| Cost of Production (mil. $) | 11,215 |
| Cost of Production ($/acre) | 170. |
| Variable ($/acre) | 119 |
| Fixed Costs ($/acre) | 51 |
| Acres Planted (Mil. acres) | 65.8 |
| Payment Yield (bu./acre) | 34.5 |
| Production (mil. bu.) | 2,547.3 |
| Exports (mil. bu.) | 1,041.7 |

**Source:** United States Department of Agriculture, Economic Research Service, Commodity Costs and Returns and Briefing Room: Wheat 2001 http://www.ers.usda.gov/briefing/wheat/

**Table 4: U.S. Peanut Sector Market and Policy Data**

| | 1998 | 1999 |
|---|---|---|
| National Quota (Mil. lbs) | 2334.0 | 2360.0 |
| Production (Mil. lbs) | 3963.4 | 3870.2 |
| Exports (Mil. lbs) | 561.0 | 800 |
| Acres planted (1000 acres) | 1521.0 | 1533.0 |
| Yield (lbs) | 2702.0 | 2711.0 |
| Prices | | |
| Quota (cents/lb) | 39.8 | 39.8 |
| Average price (cents/lb) | 28.0 | 25.6 |
| Gross Value of Production ($ Mil.) | 1126 | 992 |
| Total Costs ($/acre planted) | 717 | 719 |
| Operating Costs ($/acre planted) | 312 | 304 |
| Allocated Overhead ($/acre planted) | 405 | 415 |

**Source:** United States Department of Agriculture, Costs and Returns
http://www.ers.usda.gov/Data/CostsAndReturns/car/DATA/copest99/Peanut.xls
and Oil Crops Situation and Outlook Yearbook, Economic Research Service, 2000
http://www.ers.usda.gov/publications/so/view.asp?f=field/ocs-bb/

**Table 5A: Wheat Simulation: Production & Exports**

| | 1998 status quo LDP & PFC | LDP only | PFC only | Remove both LDP & PFC |
|---|---|---|---|---|
| No. of Farms | 43,739 | 43,739 | 43,739 | 43,739 |
| Production (farm, mil. bu.) | 0.0582 | 0.0582 | 0.0558 | 0.0558 |
| Production (total, mil. bu.) | 2,546.46 | 2,546.46 | 2,441.98 | 2,441.98 |
| (implied own-price supply elasticity) | - | 0.54 | - | - |
| Exports (total, mil. bu.) | 1,040.86 | 1,040.86 | 936.38 | 936.38 |
| Change in Exports (total, mil. bu.) | 0.0000 | 0.0000 | -104.48 | -104.48 |
| Change in export rev. /Change in payment per farm (mil.) 0% excess burden (8% excess burden) | - | 0.0000 (0.0000) | 0.0226 (0.2090) | 0.01181 (0.01903) |
| Change in TC/Change in export rev. 0% excess burden (8% excess burden) | - | .. (..) | 1.9372 (2.0925) | 3.7037 (4.0000) |

**Table 5B: Wheat Simulation: Production & Exports**

| | 1998 status quo LDP & PFC* | LDP Only* | PFC Only* | Remove both LDP & PFC* |
|---|---|---|---|---|
| No. of Farms | 38,288 | 36,975 | 36,869 | 35,348 |
| Production (farm, mil. bu.) | 2,229.11 | 2,152.65 | 2,058.42 | 1,973.48 |
| Production (total, mil. bu.) | 0.0582 | 0.0582 | 0.0558 | 0.0558 |
| (implied own-price supply elasticity) | - | 1.14 | - | - |
| Exports (total, mil. bu.) | 723.51 | 647.05 | 552.82 | 467.88 |
| Change in Exports (total, mil. bu.) | 0.0000 | -76.46 | -200.69 | -255.63 |
| Change in Export Rev / Change in payment per farm (mil.) 0% excess burden (8% excess burden) | - | 0.0181 (0.0168) | 0.0369 (0.0342) | 0.0289 (0.0268) |
| Change in TC /Change in export rev. 0% excess burden (8% excess burden) | - | 2.1922 (2.3676) | 1.0733 (1.1591) | 1.3251 (1.4312) |

*(conditional on profits>0)

**Table 6A: Wheat Simulations: Profits**

| | 1998 status quo LDP & PFC | LDP only | PFC only | Remove both LDP & PFC |
|---|---|---|---|---|
| Profits (farm) | 85,749.15 | 96,612.42 | 96,135.68 | 89,968.73 |
| Profits (total, mil.) | 3,750.58 | 3,572.23 | 3,544.43 | 3,180.19 |
| Change in Profits (total mil.) | 0.0000 | 441.02 | 473.96 | 914.98 |
| Change in Profits per Dollar, | | | | |
| 0% excess burden | - | 1.0000 | 0.9796 | 0.9893 |
| (8% excess burden) | - | (0.9259) | (0.9070) | (0.9160) |

**Table 6B: Wheat Simulations: Profits**

| | 1998 status quo LDP & PFC* | LDP only* | PFC only* | Remove both LDP & PFC |
|---|---|---|---|---|
| Profits (farm) | 103,212.94 | 96,612.42 | 96,135.68 | 89,968.73 |
| Profits (total, mil | 3,951.83 | 3,572.23 | 3,544.43 | 3,180.19 |
| Change in Profits (total mil.) | 0.0000 | 379.60 | 407.40 | -771.64 |
| Change in Profits per Dollar, | | | | |
| 0% excess burden | - | 0.9476 | 0.9305 | 0.9531 |
| (8% excess burden) | | (0.8774) | (0.8616) | (0.8825) |

*(conditional on profits>0)

**Table 7A: Deadweight Losses (8% excess burden)**

| | 1998 status quo LDP & PFC | LDP only | PFC only | Remove both LDP and PFC |
|---|---|---|---|---|
| Mean deadweight loss (farm) | -1,917.20 | -1,110.56 | -806.64 | 0.00 |
| Deadweight loss (total, mil.) | -83.86 | -48.57 | -35.28 | 0.00 |
| % of total payment | -9.07% | -10.04% | -8.00% | - |

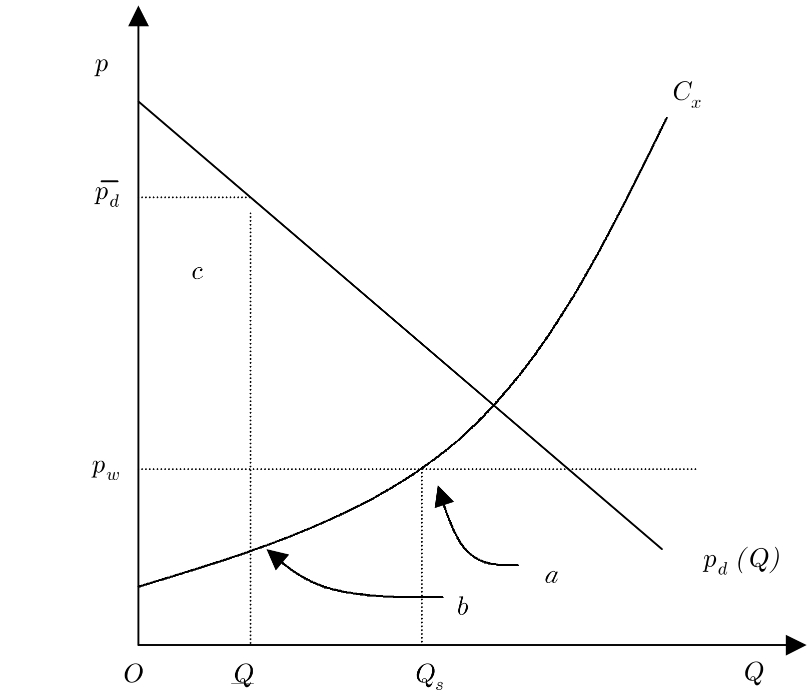
**Table 7B: Deadweight Losses (8% excess burden)**

| | 1998 status quo LDP & PFC* | LDP only* | PFC only* | Remove both LDP and PFC |
|---|---|---|---|---|
| Mean deadweight loss (farm) | -9,592.06 | -5,302.94 | -4,722.68 | 0.00 |
| Deadweight loss (total, mil.) | -367.26 | -196.08 | -174.12 | 0.00 |
| % of total payment | -45.36% | -47.94% | -46.84% | - |

*(conditional on profits>0)

*Figure 1: Decoupled Consumer vs. Taxpayer Financed Infra-marginal Production Subsidies*

*(a) Consumer Transfer: e.g. U.S. peanut policy*




*(b) Taxpayer transfer: e.g. pre-FAIR U.S. policy or U.S. PFCs.*

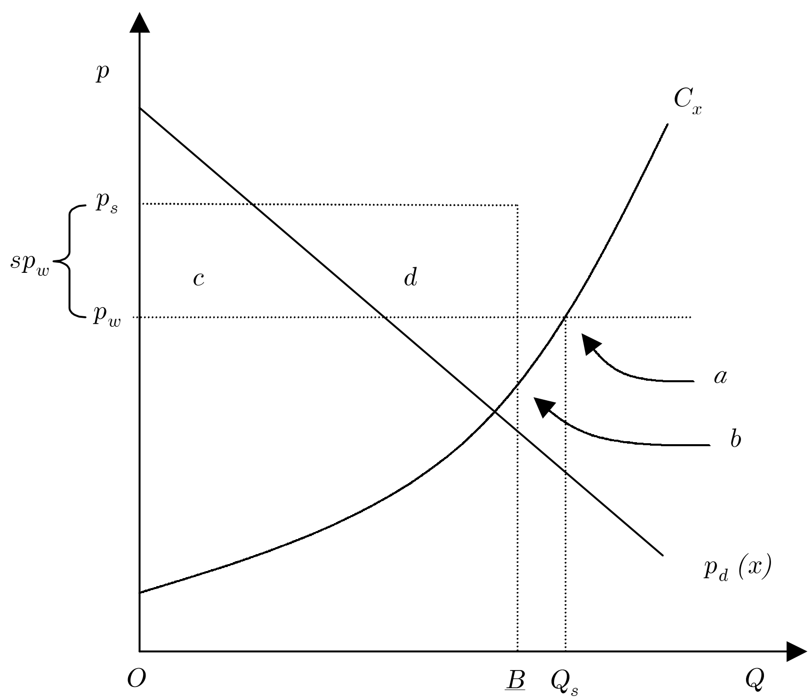
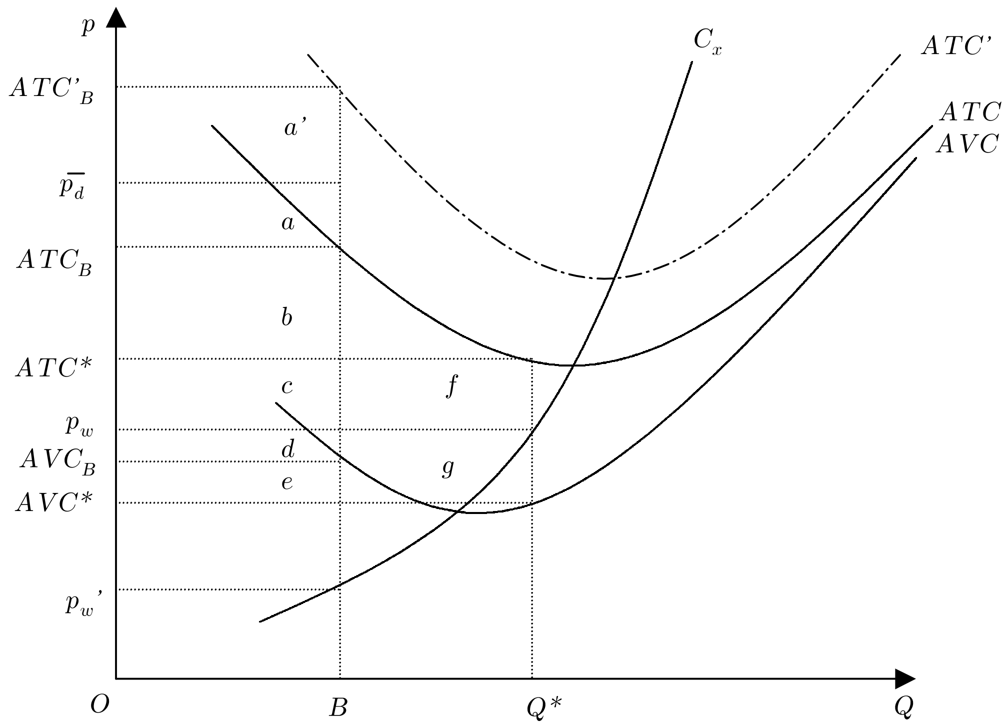


*Figure 2: Effects of Direct Income Payments on Fixed Costs andOutput*

*(a) Positive gross of subsidy Profits at $Q^*$ and $B$ for $ATC'$ and $AVC$ (if $a' < e + g$).*
*Positive gross of subsidy Profits at $Q^*$ and $B$ for $ATC$ and $AVC$.*

.




*(b) Positve gross of subsidy Profits at $B$ and*
*Positive gross of subsidy profits at $Q^*$ (if $a + d > f$).*

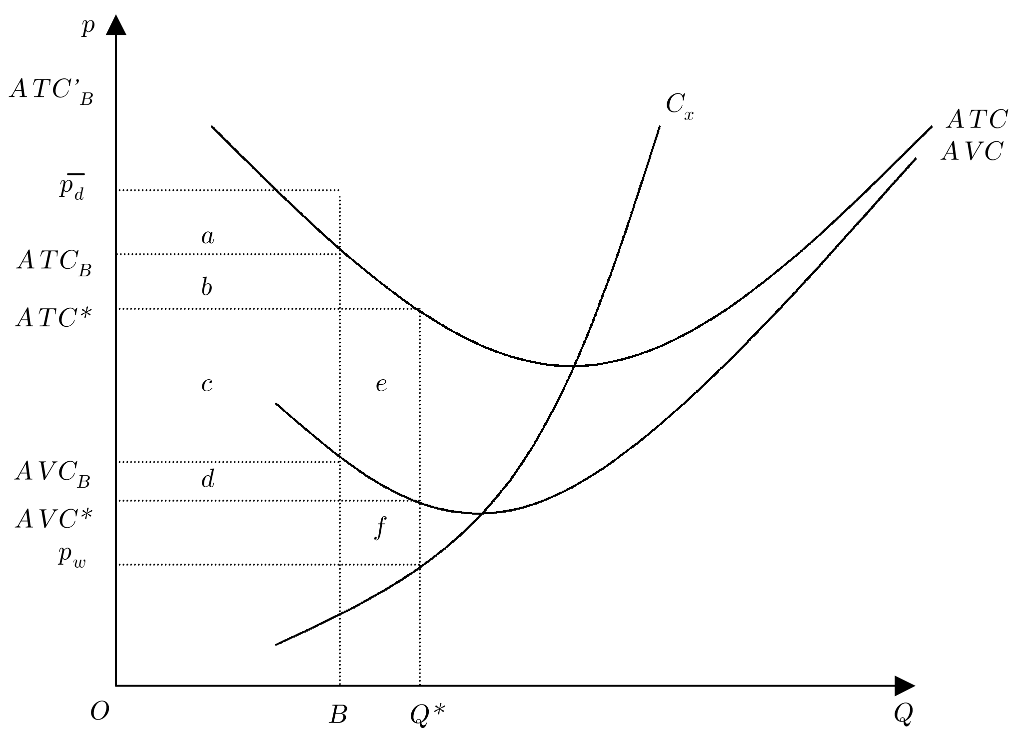


*Figure 3: Output and Exports (Industry-Level)*

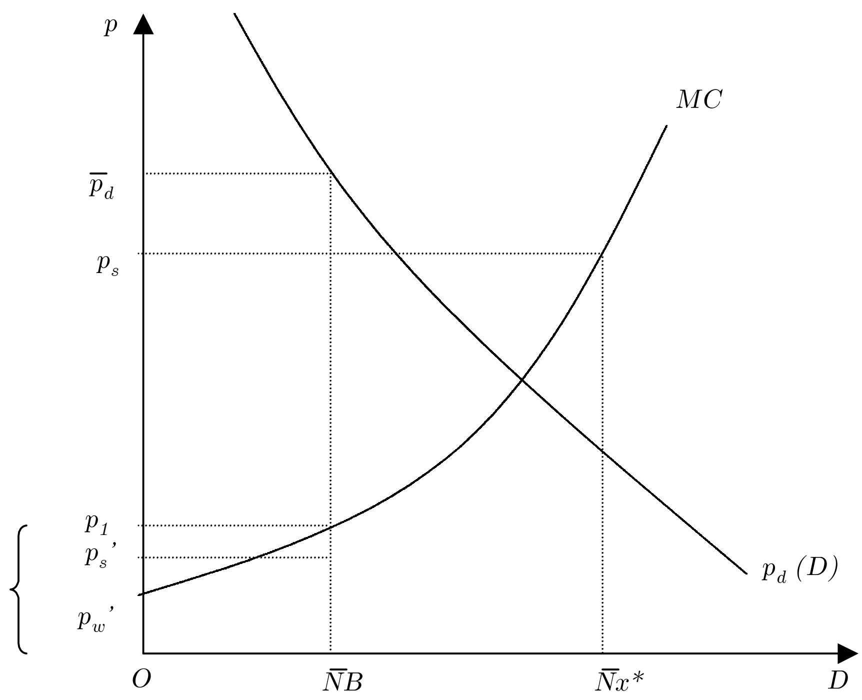



*Figure 4: Deadweight Loss and Coupled Payments*

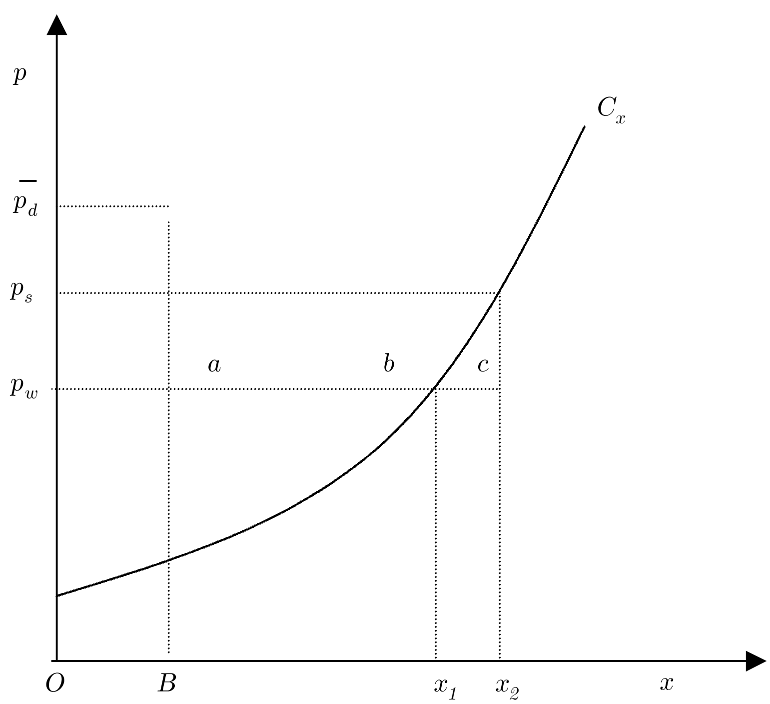


*Figure 5: Hazard Rates*

*(a) Variance and Hazard Rates (mean fixed cost ($\underline{F}_{98}$)= \$21,386)*

*(b) Mean Fixed Cost and Hazard Rates (standard deviation (s.d.$_{98}$)=\$74,423)*

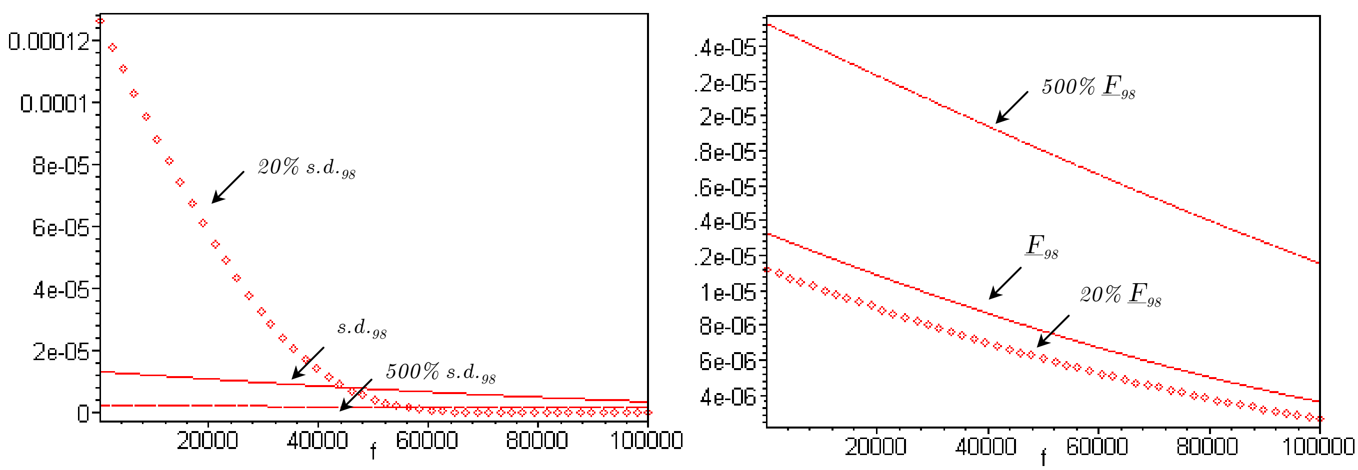
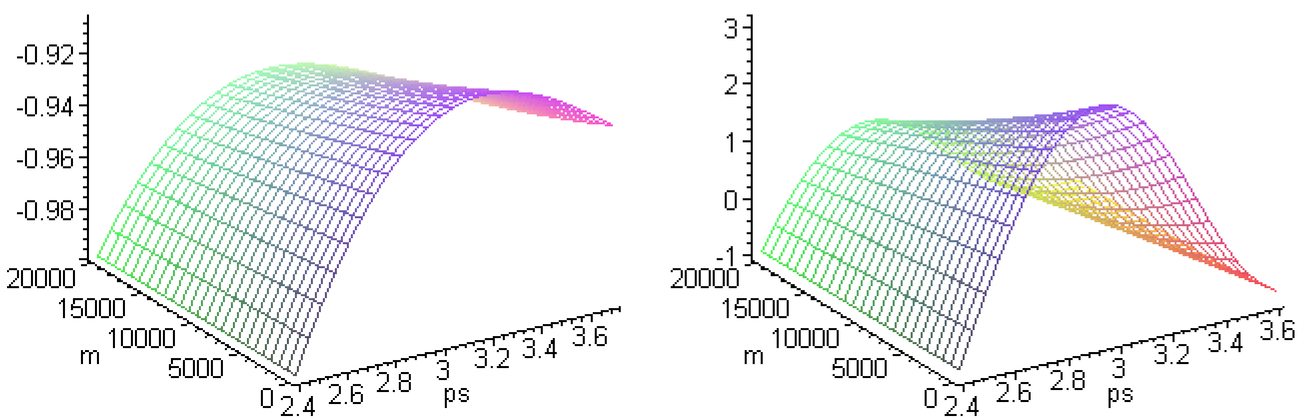



*Figure 6: Output and Trade Distortion of Decoupled and Coupled Payments*

*(a) s.d.= s.d.$_{98}$, $\underline{F}$= $\underline{F}_{98}$, own-price elasticity of supply (farm) = 0.52*

*(b) s.d.= 20% s.d.$_{98}$, $\underline{F}$= 500% $\underline{F}_{98}$, own-price elasticity of supply (farm)=1.22*



## OTHER A.E.M. WORKING PAPERS

| WP No | Title | Fee (if applicable) | Author(s) |
|---|---|---|---|
| 2001-15 | Market Access Rivalry and Eco-Labeling Standards: Are Eco-Labels Non-tariff Barriers in Disguise? | | Basu, A. K. and N. H. Chau |
| 2001-14 | An Economic Evaluation of the New Agricultural Trade Negotiations: A Nonlinear Imperfectly Competitive Spatial Equilibrium Approach | | Kaiser, H. M., N. Suzuki and K. Maeda |
| 2001-13 | Designing Nonpoint Source Pollution Policies with Limited Information about Both Risk Attitudes and Production Technology | | Peterson, J. M. and R. N. Boisvert |
| 2001-12 | Supporting Public Goods with Voluntary Programs: Non-Residential Demand for Green Power | | Fowlie, M., R. Wiser and D. Chapman |
| 2001-11 | Incentives, Inequality and Allocations | | Kanbur, R. and M. Tuomala |
| 2001-10 | Rural Poverty and the Landed Elite: South Asian Experience Revisited | | Hirashima, S. |
| 2001-09 | Measuring the Shadow Economy | | Kyle, S. and A. Warner |
| 2001-08 | On Obnoxious Markets | | Kanbur, R. |
| 2001-07 | The Adoption of International Labor Standards | | Chau, N. and R. Kanbur |
| 2001-06 | Income Enhancing and Risk Management Perspective of Marketing Practices | | Peterson, H. and W. Tomek |
| 2001-05 | Qual-Quant: Qualitative and Quantitative Poverty Appraisal: Complementarities, Tensions and the Way Forward | | Kanbur, R. (Editor) |
| 2001-04 | Fifty Years of Regional Inequality in China: A Journey Through Revolution, Reform and Openness | | Kanbur, R. and X. Zhang |
| 2001-03 | Cross-Border Externalities, International Public Goods and Their Implications for Aid Agencies | | Kanbur, R. |
| 2001-02 | The Role of Curvature in Estimating Accurate Dual Functions | | Tauer, L. |

Paper copies are being replaced by electronic Portable Document Files (PDFs). To request PDFs of AEM publications, write to (be sure to include your e-mail address): Publications, Department of Applied Economics and Management, Warren Hall, Cornell University, Ithaca, NY 14853-7801. If a fee is indicated, please include a check or money order made payable to Cornell University for the amount of your purchase. Visit our Web site (*http:// do 3 e c co .os ar.com/research/workpaper3.html*) for a complete list of recent bulletins.