Are Subsidies Decoupled from Production in the Presence of Incomplete Financial Markets?

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Abstract

This paper contributes to the decoupled subsidies literature by identifying mechanisms through which production decisions of risk averse agents can be decoupled from agricultural subsidies. Ignoring the roles played by incomplete financial markets and the timing of subsidy payments causes the production distortions induced by the subsidy in the case of farmers facing stochastic technologies and stochastic markets to be overstated. I present conditions that ensure the subsidy is decoupled from production in the presence of incomplete financial markets under the pricing rule induced by the market. This amounts to showing how farmers with different risk preferences, but the same technology, make the same production decisions over consumption sets where separation induced by financial markets holds. Second, conditional on farmers' ability to transfer consumption across time, which itself depends on financial markets' potential to replicate uncertain consumption, the timing of subsidy payments may affect the size of production distortions.

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1 Introduction

Subsidy support for agriculture remains a topic of serious debate in the policy arena. With various justifications and levels of success, governments around the world have diligently sought to support domestic agriculture. In general, direct production subsidies of this nature are known to induce trade distortions. Awareness of such distortions eventually resulted in the Agreement on Agriculture (AOA), under which member countries of the World Trade Organization (WTO) are obligated to switch their agriculture support from subsidies paid according to the number of units produced (coupled support) to subsidies paid independently of current prices, yields or input use (decoupled support). Proponents of this change argue that it allows governments to continue supporting the farm income, while dispensing with production distortions.

Subsequent literature has since investigated if the new WTO sanctioned support remains, nonetheless, indirectly linked to production and, as such, a source of trade distortions. To date, a consensus concerning the linkage between decoupled subsidies and production decisions still seems to be missing. It has been shown, first by Hennessy (1998), that decoupled programs can in fact be linked to production distortions through indirect channels, such as wealth and insurance effects (Hennessy, 1998; Sckokai & Anton, 2005; Sckokai & Moro, 2006; Femenia et al., 2010), relaxation of credit constraints (Ciaian & Swinnen, 2009; Goodwin & Mishra, 2006), appreciation of land values and rents (Roberts et al., 2003; Goodwin et al., 2003), and changes in both labor allocation and expectations regarding future policy updates (Lagerkvist & Olson, 2002; Sumner, 2003; Lagerkvist, 2005; McIntosh et al., 2007; Bhaskar & Beghin, 2010) among others. However, with notable exceptions, empirical evidence has failed to support such theory. A review of the literature provided by Bhaskar & Beghin (2009) highlights the finding that the coupling effect seems to be present, albeit with a negligible impact except in the case of land values.

More puzzling is the finding that apart for selected few papers, the role played by

financial markets, in allowing farmers to transfer consumption across time, and as such, their effect on the potential link between subsidy and production decisions, is largely ignored or trivialized. A salient characteristic of rational producers is that, irrespective of their risk preferences, they never forego opportunities to risklessly raise profit. It is well understood that, in the presence of complete financial markets, farmers' production decisions are independent of their risk attitudes (Chambers & Quiggin, 2009; Magill & Quinzii, 1996). Subsidies are no exception. In this case, agricultural subsidies are decoupled from production since farmers solve a profit maximization problem under the pricing kernel induced by the financial markets. Furthermore, under certain spanning conditions, similar decoupling results are extended to incomplete financial markets, which are a closer representation of the real world financial instruments available to farmers.

A closely related missed opportunity in explaining deflated coupling effects is accounting for how the timing of subsidy payments affects the link between subsidies and production decisions outside the market span formed by the incomplete financial markets. For instance, the European Union (EU), during the 2003 Mid Term Review(MTR), introduced a single farm payment (SFP) per hectare of land, an income support scheme which is decoupled from production under WTO regulations.[1] The SFP is the current single most important subsidy system through which the EU supports domestic agriculture. It is designed to allow subsidy payments to be made to beneficiaries between December 1st and June 30th of the following calendar year (Europe, 2014). Given the current design, farmers receive subsidy payments after all, or at least part of, their production decisions are made.

The purpose of this paper is to illustrate that ignoring the roles played by incomplete financial markets and the timing of subsidy payments causes the production distortions induced by the subsidy in the case of farmers facing stochastic technologies and stochastic markets to be overstated. First, I present conditions that ensure the subsidy is decoupled from production in the presence of incomplete financial markets under the pricing

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[1]SFP is also known as the Single Payment Scheme.

rule induced by the market. This amounts to showing how farmers with different risk preferences, but the same technology, make the same production decisions over consumption sets where separation induced by financial markets holds. Second, I demonstrate how the timing of the subsidy payments can, in fact, be responsible for reducing or even eliminating production distortions outside the consumption set where separation applies. Conditional on farmers' ability to transfer consumption across time, which itself depends on financial markets' potential to replicate uncertain consumption, the timing of subsidy payments may affect the size of production distortions.

In effect, a subsidy coupled via the indirect mechanisms identified by the literature may become decoupled from production due to the separation induced in incomplete financial markets and the timing of its payments outside the separable consumption set. These findings help reconcile some of previous theoretical findings with the empirical evidence.

2 Background

Decoupled subsidies are defined by WTO as a type of governmental support for domestic agriculture which is paid independently of current production, current prices or factor use. Starting with the Uruguay Round Agreement on Agriculture in 1994, governmental support for agriculture was classified into three "boxes" based on its trade distortions. The most trade distorting support is contained in the amber box. Less trade distorting subsidies, which require production caps, are contained in the blue box. Finally, minimal or no distortionary subsidies are grouped in the green box. Decoupled subsidies are included in the most latter category.

To comply with the AOA requirements and avoid criticism of providing unfair support to their domestic agriculture, WTO member nations were required to reduce the payments coupled to production and increased decoupled income support. In 1996, the US adopted

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the Federal Agriculture Improvement and Reform (FAIR) Act which made the payments independent of current production and farm prices. Under the FAIR Act the previous coupled support was replaced by the Production Flexibility Contracts (PFC), which was designed to allow farmers more freedom in choosing among the program crops (i.e. corn, wheat, cotton, etc.). The PFC payments were based on historical production figures and they were to be phased out by the time of the FAIR Act's expiration in 2002. To remain eligible under PFC, farmers were required to comply with certain land use restrictions (i.e. land was to be kept in good agricultural use, fruits and vegetables were not eligible under PFC). [2]

The PFC in 2002 was replaced by the Farm Security and Rural Investment (FSRI) Act, which employed direct payments and instituted the Counter Cyclical Program. The FSRI Act did not eliminate the previous decoupled support, as it was supposed to, but instead allowed farmers to update their historic base acreage and yields. This brought under question the extent to which the payments were actually decoupled, since anticipation of future updating of the historical figures could break the decoupled nature of the program.

The Food, Conservation, and Energy Act of 2008 continued the decoupled support of FSRI, but allow producers to enroll in the Average Crop Revenue Election (ACRE) program. The newly created ACRE permitted farmers to receive payments conditional on both state and farm levels being meet and at the expense of a portion of their decoupled payments.

Similarly, in June 2003, the EU farm ministers decided upon a change of direction in the Common Agriculture Policy (CAP), in order to quell the criticism that the EU was providing its farmers with an unfair competitive advantage through its agricultural support mechanism. The new support instrument, called the Single Payment Scheme or Single Farm Payment, was designed to remove the link between subsidies and produc-

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[2] Just & Kropp (2013) argue that crop restrictions, such the exclusion of fruits and vegetables from PFC, could determine production distortions if profits for excluded crops increase compared to eligible crops, since direct payments would encourage farmers to limit the land allocation from excluded crops. However, high cost of technology conversion, among others, puts into question the profitability of excluded crops.

tion of specific crops, allowing the farmers freedom to produce to meet market demand while promoting environmentally and economically sustainable farming. [3] Under the new support scheme, farmers were granted payments conditional on the number of eligible hectares at their disposal and the allotted payment entitlements based on reference amounts (i.e. direct payments each farmer received in the period 2000-2002). However, each member state had freedom in deciding the specific details of SPS design and calculations as long as it followed an agreed upon set of regulations and procedures. The member states could choose to implement SPS based on a historic (basic), a regional (flat rate) or a mixed (hybrid) approach. Under the historic approach, farmers are granted entitlements based on the number of hectares farmed and direct payments received in the reference period. In this case, payments vary across farmers. Under the flat rate approach, the value of an entitlement is calculated at the region level. The value of a single entitlement in a region is equal to the sum of payments received by the farmers in that region divided by the number of eligible hectares declared by the farmers of the region in the year of SPS introduction. Each farmer is granted a number of entitlements equal to the number of eligible hectares declared in the year of SPS introduction. Finally, the hybrid model is a mixture of the two previous approaches.

Previously, the EU amended its CAP in 1992 and 1999. The MacSharry reform in 1992 saw the introduction of per hectare compensatory payments and compulsatory land set-aside requirements attached to these payments. In 1999, CAP prices were further aligned with market prices.

In theory, moving policy away from supporting agricultural output to providing support for the land should increase acreage and decrease yields, with the total impact on production depending on the magnitude of the two effects. Due to the relative rigidity of land adjustment, it is expected that production should decrease (Dewbre et al., 2001). This is one of the main justifications employed by the supporters of decoupled payment policy. However, Hennessy (1998) pointed out that support policies which are decoupled

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[3] http://ec.europa.eu/agriculture/markets/sfp/index_en.htm

in a deterministic framework (or under risk neutrality) influence production decisions of risk averse producers facing uncertainty, since they can decrease risk aversion (wealth effects) and income variability (insurance effects). Subsequently, other channels, such as credit constraints, labor allocations and expectations towards future policy updates among others, were shown to determine production distortions.

Surprisingly, empirical studies have not found evidence to support the theoretical arguments. While the coupling effect seems to be present, except for the impact on the land values, its magnitude is negligible or not statistically significant (Bhaskar & Beghin, 2009). For instance, Goodwin & Mishra (2006) evaluate empirically the effects of PFC and market loan assistance on the production decisions of Corn Belt farmers using 1998-2001 farm level data from USDA's agricultural resource management survey (ARMS). The paper estimates acreage equations for corn, soybean, and wheat, and finds the acreage elasticity for these crops to range between 0.025 to 0.035, suggesting that even a large increase in the decoupled payments would not significantly increase acreage. Insurance effects (measured by an interaction term between PFC and the ratio of insurance bill to total expenditure) and wealth effects (total assets, less total debts, plus PFC payments) were found to be insignificant. Femenia et al. (2010) revisits the wealth effects using a simulation model applied to a representative US corn farm. They find modest production distortions (1.11%), as well as low wealth elasticity of production (0.03).

Sckokai & Anton (2005) and Sckokai & Moro (2006) study the effects of changes in the CAP after 1992 reform and simulate the impact of 2003 MTR. They find that wealth effects are positive but small, while insurance effects are more important in the context of production distortions induced by the policy change. They conclude that area payments are partially decoupled when comparing output response to area payments versus output response to direct price support.

Recently, Kazukauskas et al. (2013) used the variation across countries in the timing of the implementation of 2003 MTR to identify the causal relationship between the decoupling of direct payments and farmers decision to disinvest (i.e. selling farm capital).

They find that the probability of a farm disinvesting decreases due the policy change for all farms, except those engaged in livestock production and those already in the process of leaving the sector. This suggests the subsidy is completely coupled to production, since no rational farmer will increase inputs without increasing the outputs. However, the paper accounts only for the sold farm capital (i.e. disinvestment). It can be argued, that if the introduction of subsidy determines farmers to stop purchasing capital, it will also determine them to stop selling it. In which case, the subsidy effectively determines disinvestment (i.e. farmers stop replacing capital and use the old assets until wear and tear). As such, the subsidy is only partially coupled via the land.

The lack of agreement between theory and empirical evidence suggests something is missing. First, it is difficult to make a strong case that the subsidy is the only risk averting instrument available to farmers facing stochastic technology and stochastic markets. For example, Aleem (1990) makes a rather compelling case for the existence of financial markets even under severe information asymmetry regarding market participants. Failing to account for alternatives available to farmers can misrepresent the magnitude of subsidies' effect on producers decisions. For instance, in the presence of complete financial markets, farmers' production decisions are independent of their risk attitudes (Chambers & Quiggin, 2009; Magill & Quinzii, 1996). In this case, the wealth and insurance effects induced by the subsidy are zero and the payments are decoupled from production. Opposite, in the absence of financial markets, a lump sum subsidy will induced insurance and wealth effects for the producer with decreasing absolute risk averse(DARA) preferences (Hennessy, 1998). As such, the potential trade distortions, induced by decoupled subsidies, are bound to depend on the range of financial instruments available to farmers.

Second, the timing of subsidies payments, as the EU Single Farm Payment shows, does not always match the timing of production decisions. In the absence of complete financial markets, the farmer ability to transfer consumption across time can affect the impact of subsidies on production decisions conditional on payments timing.

3 Theoretical Model

In this section, I investigate the impact of the subsidy payments timing on the optimal decisions of agents facing stochastic production technology under different assumptions regarding financial markets (i.e. no financial markets, complete and incomplete financial markets).

I model competitive farmers' behavior facing stochastic production and stochastic markets in a two period setting. The first period (i.e. period 0) is certain, whereas the second period (i.e. period 1) is stochastic. Uncertainty in period 1 is represented by a discrete and finite state space $\Omega = \{1, 2, \ldots S\}$, where each element of Ω is referred to as a state of Nature, or just as state. Uncertainty is resolved by Nature (an unbiased player) choosing an element of Ω. Once Nature chooses the state, all stochastic choices relevant to the farmer are resolved.[4]

The farmer maximizes the utility of consumption over two periods (i.e. $W : \mathbb{R}_+ \times \mathbb{R}_+^S \to \mathbb{R}_+$ is C^2). The only structural restriction over the utility function is that the farmer strictly prefers more period 0 consumption to less (i.e. if $c_0^\star > c_0$, then $W(c_0^\star, \mathbf{c}_1) > W(c_0, \mathbf{c}_1)$) and at least weakly prefers more period 1 consumption to less (i.e. if $\mathbf{c}_1^\star \geq \mathbf{c}_1$, then $W(c_0, \mathbf{c}_1^\star) \geq W(c_0, \mathbf{c}_1)$).

The agent can allocate consumption across period 0 and period 1 using a combination of stochastic agricultural output and financial portfolio payoffs. Period 0 is nonstochastic and the farmer makes the production and financial choices before the uncertainty is resolved (i.e. before Nature picks a state).

In the first period, the farmer has an initial endowment $e_0 \in \mathbb{R}_+$ and incurs the production cost $c(\mathbf{w}, \mathbf{z})$, where $c(\mathbf{w}, \mathbf{z}) = \min_{\mathbf{x}}\{\mathbf{w}\mathbf{x} : \mathbf{x} \in X(\mathbf{z})\}$ is the cost of producing the stochastic output $\mathbf{z} \in \mathbb{R}_+^S$, $\mathbf{x} \in \mathbb{R}_{++}^N$ is the input vector required to produce $\mathbf{z}$ and $\mathbf{w} \in \mathbb{R}_{++}^N$ is the input price vector. Both $\mathbf{x}$ and $\mathbf{w}$ are nonstochastic (i.e. they are known at the time production decisions are being made). The subsidy $\mathbf{p} \in \mathbb{R}_+$ is a lump sum

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[4]Technically, the uncertainty is modeled as a probability space (S, Ω, π) where S is the set of states of "Nature", π is a probability measure, Ω represents the measurable events of S (σ- algebra of S).

payment to the farmer in the first period if $\delta = 0$ or in the second period if $\delta = 1$.[5] In the second period, the farmer receives the revenue from the sale of state contingent output z_s, where z_s is the output in state of nature s, and the subsidy $p \in \mathbb{R}_+$ (if $\delta = 1$). For simplicity the state contingent output price was assumed 1.[6]

The farmer can trade in the financial market by buying or selling financial assets $h = (h_1, \ldots, h_J) \in \mathbb{R}^J$, where $h_j \in \mathbb{R}$ is the amount of the jth asset (i.e. the asset with payoff represented by the j column of the $S \times J$ payoff matrix $\mathbf{A}$). The price of the jth asset is $v_j \in R_{++}$. Following the convention that there are no redundant assets in the market (i.e. column vectors of matrix $\mathbf{A}$ are linear independent), $J \leq S$.

The farmer seeks to:

$$\max_{c_0, \mathbf{c_1}} W(c_0, \mathbf{c_1})$$

where

$$c_0 = e_0 - c(\mathbf{w}, \mathbf{z}) + (1 - \delta)p + \sum_{j \in J} v_j h_j$$

$$\mathbf{c}_1 \leq \mathbf{z} + \mathbf{Ah} + \delta p \mathbf{1}^S$$

Let $\mathbf{c}_1^\star \in \mathbb{R}^S$ be the optimal consumption level in the second period. Then the farmer solves :

$$\min_{\mathbf{z}, \mathbf{h}} \left\{ c(\mathbf{w}, \mathbf{z}) + \sum_{j \in J} v_j h_j : \mathbf{z} + \mathbf{Ah} + \delta p \mathbf{1}^S \geq \mathbf{c}_1^\star \right\}$$

Suppose the contrary, that the farmer chooses $\hat{\mathbf{z}}$ and $\hat{\mathbf{h}}$ that are not cost minimizing, but that yield $\mathbf{c}_1^\star$. This cannot be optimal since choosing

$$\min_{\mathbf{z}, \mathbf{h}} \left\{ c(\mathbf{w}, \mathbf{z}) + \sum_{j \in J} v_j h_j : \mathbf{z} + \mathbf{Ah} + \delta p \mathbf{1}^S \geq \mathbf{c}_1^\star \right\} \tag{1}$$

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[5]The timing δ can take any value in the interval $[0, 1]$. Values other than 0 and 1 will reflect that portion of the subsidy was paid in period 0 and the remaining in period 1

[6]The concerned reader can think of $\mathbf{z}$ as the state contingent revenue instead of stochastic output.

the agent saves

$$c(\mathbf{w}, \hat{\mathbf{z}}) + \sum_{j \in J} v_j \hat{h}_j - \min_{\mathbf{z}, \mathbf{h}} \left\{ c(\mathbf{w}, \mathbf{z}) + \sum_{j \in J} v_j h_j : \mathbf{z} + \mathbf{A}\mathbf{h} + \delta p \mathbf{1}^S \geq \mathbf{c}_1^{\star} \right\} > 0$$

which can be used to strictly increase period two consumption.

Let $\mathbf{M} = \{ \mathbf{c} \in \mathbb{R}^S : \mathbf{c} = \mathbf{A}\mathbf{h}, \mathbf{h} \in \mathbf{R}^J \}$ be the financial market subspace. The set $\mathbf{M}$ is the column space of the payoff matrix $\mathbf{A}$ and is the set of all second period consumption vectors that can be replicated through financial markets. The farmer can assemble any consumption vector in the market subspace $\mathbf{M}$ by choosing an appropriate portfolio $\mathbf{h}$. The size of the payoff matrix $\mathbf{A}$ column rank (given by J) is an indicator of the financial market's ability to replicate consumption in the second period. I follow the convention that there are no redundant assets in the market (i.e. column vectors of matrix $\mathbf{A}$ are linearly independent) and, as such, $J \leq S$.

3.1 No Financial Markets

If $J = 0$, there are no financial assets in the market and the farmer can attain the second period consumption only through the stochastic technology. Many of the previous results, in the decoupled literature, were derived assuming no financial markets, despite the shortcomings of this assumption. For example, Aleem (1990) provides evidence of informal financial networks that rise in the absence of any formal financial instruments under severe information asymmetries. Assuming interior solutions,

$$\mathbf{z}_{|\mathbf{c_1}^{\star}}^{\star} = \mathbf{c_1}^{\star} - \delta p \mathbf{1}^S \tag{2}$$

The optimal level of stochastic output $\mathbf{z}$, conditional on $\mathbf{c_1}^{\star}$, is a decreasing function of the timing of subsidies' payments (i.e. δ) and of the subsidy p. If the subsidy is paid in the first period as compared to the second period, the optimal stochastic output $\mathbf{z}_{|\mathbf{c_1}^{\star}}^{\star}$ increases. The intuition is simple: if the subsidy is paid in the second period (i.e. $\delta = 1$),

than the second period consumption $\bar{\mathbf{c}}_1$ increases by the amount of the subsidy. On the other hand, through the marginal rate of substitution across time, consumption in the first period needs to increase. In order for this to happen, the farmer has to reduce the stochastic output produced in period zero. Similarly, if the subsidy is paid in the first period (i.e. $\delta = 0$), the consumption in first period increases by the amount of the subsidy. Because of the intertemporal rate of substitution between consumption across time, the second period consumption will increase. For this to happen, the farmer has to increase the stochastic output. A similar intuition applies in the case of changes in the size of subsidy p. This is the direct effect of the subsidy timing on the optimal stochastic output $\mathbf{z}^{\star}_{|\mathbf{c}_1^{\star}}$. The indirect effect of the payments' timing is through the changes in the optimal consumption, since $\mathbf{c}_1^{\star}$ is a function of the timing δ and subsidy p.

Solving for the optimal level of consumption, replace the optimal level of stochastic output in the farmer's problem to obtain[7]:

$$\max_{\mathbf{c}_1} W(e_0 + (1 - \delta)p - c(\mathbf{w}, \mathbf{c}_1 - \delta p \mathbf{1}^S), \mathbf{c}_1)$$

Assuming an interior solution, first order conditions show:

$$\frac{\partial W/\partial c_s}{\partial W/\partial c_0} = \frac{\partial c(\mathbf{w}, \mathbf{z})}{\partial c_s}$$

The marginal cost of increasing consumption by one unit in the state of nature s equals the marginal rate of substitution between consumption in state s and consumption at date 0. By non-negativity of the stochastic output, it follows that $\mathbf{c}_1 \geq (1 - \delta)p \mathbf{1}_S$

[Figure 1 inserted here]

Figure 1 shows the farmers decisions in the absence of financial markets under different subsidy payments schedules (i.e. $\delta = 1$ and $\delta = 0$). The vector $\overrightarrow{OA}$ is the optimal production choice in the absence of the subsidy. The location of point A is determined by the

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[7]Assuming $\nabla W_{c_0, \mathbf{c}_1}(c_0, \mathbf{c}_1) \gg 0$ (preferences are strictly increasing in every state of nature) or $X(\mathbf{z}) = \mathbb{R}^S_+$ (i.e. stochastic technology is flexible)

cost structure and agent's consumption preferences. The cost structure is drawn to represent an inherently risky technology (i.e. it is more expensive to produce the trivial lottery $E(\mathbf{z})\mathbf{1}^S$ than it is to produce $\mathbf{z}$). Intuitively, it should be more expensive to produce in an uncertainty free environment (i.e. greenhouse), than in the field facing weather vagaries. If the farmer receives a subsidy, assumed to be paid in the first period, the consumption in the second period, conditional on the intermteporal rate of substitution, should increase. Under mild assumptions regarding preferences over uncertain consumption, wealth and insurance effects would suggests the risk averse agent chooses the new consumption vector further away from bisector (i.e. more risky consumption). Let the point B be the new second period stochastic consumption. In the absence of financial markets, farmer can attained the new consumption only by producing the stochastic output $\overrightarrow{OB}$.[8] This is an example of what the previous literature (i.e. Hennessy (1998)) identified as being the coupled effect of a lump sum subsidy in the presence of uncertainty.

If the payments are delayed (i.e. $\delta = 1$), the farmer receives the subsidy (i.e. $\overrightarrow{CB}$) in the second period. The absence of financial markets forces the agent to consume the subsidy in the second period. As such, assuming timing does not changes his optimal second period consumption (i.e. point B), the farmer will choose to produce $\overrightarrow{OC}$. The timing of subsidy payments determines a production change from $\overrightarrow{OB}$ to $\overrightarrow{OC}$.

3.2 Complete Financial Markets

If $J = S$, the financial markets are called complete. When financial markets are complete any consumption vector in the second period can be attained by choosing an appropriate financial portfolio $\mathbf{h}$. In other words, any possible lottery (i.e. state contingent consumption) in the second period can be constructed with the assets provided by financial markets. Furthermore, any two agents with the same period 1 consumption vector, using the same stochastic production technology, will agree on the portfolio choice independent

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[8]This assumes that the agent's preferences are strictly increasing in consumption or that the technology is flexible. Fig. 2 and Fig. 3 show examples where this does not hold and the agent is forced to choose a stochastic output that dominates the optimal consumption in some states of nature.

of their risk preferences. In complete financial markets, separation between consumption and production decisions occurs because of the unique pricing rule induced by the markets.

Solving for the optimal portfolio in problem (1), we have $\mathbf{h}_{|\mathbf{c}_1^\star, \mathbf{z}}^\star = \mathbf{A}^{-1}[\mathbf{c}_1^\star - \delta p \mathbf{1}^S - \mathbf{z}]$. Replacing it in the original problem, the farmer solves:

$$e_0 + (1 - \delta)p + \max_{\mathbf{z}} \left\{ \mathbf{q}(\mathbf{v})\mathbf{z} - c(\mathbf{w}, \mathbf{z}) \right\} - \mathbf{q}(\mathbf{v})[\mathbf{c}_1^\star - \delta p \mathbf{1}^S] \tag{3}$$

where $\mathbf{q}(\mathbf{v}) = \mathbf{v}\mathbf{A}^{-1}$ is the vector of discounted prices the agent receives for the stochastic output $\mathbf{z}$ in the second period under complete financial markets. Since financial markets are complete, there exists a portfolio $\mathbf{h}$ such that $\mathbf{z} = \mathbf{A}\mathbf{h}$. Replacing $\mathbf{z}$ rewrites the maximization problem as $\max_{\mathbf{h}}\{\mathbf{v}\mathbf{h} - c(\mathbf{w}, \mathbf{A}\mathbf{h})\}$. This is the profit function under the financial prices $\mathbf{v}$ using the stochastic production technology. In the presence of complete financial market, the agent chooses the level of stochastic output by solving a profit maximization problem which is independent of the subsidy or subsidy timing. As such, the subsidy (in this case a lump sum transfer) is decoupled from production decisions.

Substituting for the optimal consumption in the utility maximization problem we have:

$$\max_{\mathbf{c_1}} W\left(e_0 + \Pi(\mathbf{q}(\mathbf{v}), \mathbf{w}) + (1 - \delta)p + \delta p \sum_S q_s(v) - \mathbf{q}(\mathbf{v})\mathbf{c_1}, \mathbf{c_1}\right) \tag{4}$$

where $\Pi(\mathbf{q}(\mathbf{v}), \mathbf{w})$ is the profit function for the stochastic output, $\Pi(\mathbf{q}(\mathbf{v}), \mathbf{w}) = \max_{\mathbf{z}}\left\{\mathbf{q}(\mathbf{v})\mathbf{z} - c(\mathbf{w}, \mathbf{z})\right\}$. Since $\sum_S q_s(v) \leq 1$, the subsidy is effectively discounted due to the payments' delays (i.e. $\delta p + (1 - \delta)p \sum_S q_s(v) < p$).[9].

Assuming an interior solution, first order conditions are:

$$\frac{\partial W / \partial c_s}{\partial W / \partial c_0} = q_s(\mathbf{v})$$

The marginal rate of substitution between consumption in state s and consumption at

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[9]$\sum_S q(v)_s$ is the price today of an asset that promises to deliver with certainty tomorrow one unit of consumption. It follows that, $\sum_S q(v)_s \leq 1$.

date 0 equals the price of financial portfolio in state s (which is the cost in units of date 0 consumption of a unit increase in holding of portfolio $\mathbf{h}$ in state s). This is a well known separation result, that in the presence of complete financial markets the vector of the marginal rate of substitution of all agents (whose optimal consumption is interior) are the same and can be deduced from the assets prices. Furthermore, the first order condition for the optimal stochastic output (obtained from the profit maximization) shows:

$$\frac{\partial c(\mathbf{w}, \mathbf{z})}{\partial z_s} = q_s(\mathbf{v})$$

In complete financial markets the agents' choices are guided by the market. The optimal stochastic output is found as a solution to profit maximization under pricing rule induced by the financial markets.

[Figure 4 inserted here]

Figure 4 shows the farmers decisions in the presence of complete financial markets under different subsidy payments schedules (i.e. $\delta = 1$ and $\delta = 0$). Let the optimal consumption vector in the absence of the subsidy be at the point A. The complete markets are represented by two Arrow securities (one for each axes). Because financial markets are complete, all stochastic consumption vectors can be replicated, and priced, in the market. Furthermore, all agents, independent of their risk preferences, agree on the value of any stochastic consumption.

Denote $\overrightarrow{OB}$ the optimal production choice in the absence of the subsidy. The location of B is determined as a solution to the profit maximization problem under the priced induced by the financial markets (i.e. the slope at A).

Suppose the farmer receives a subsidy, assumed to be paid in the first period, and let the point C be the new second period stochastic consumption. Since $\overrightarrow{OB}$ is a profit maximizing solution and financial assets are linear priced, any change in the choice of stochastic output (i.e. $\overrightarrow{OB}$) will determine loses. As such, the farmer can attain the new consumption (i.e. point C) only via financial markets (i.e. portfolio $\overrightarrow{BC}$).

If the payments are delayed (i.e. $\delta = 1$), the farmer receives the subsidy (i.e. $\overrightarrow{BD}$) in the second period. Since markets are complete, at equilibrium, the farmer is indifferent between consuming the subsidy in the second period (i.e. $\overrightarrow{BD}$) or going "short" against it. If this would not be true, the farmer would be faced with an arbitrage opportunity, which contradicts the existence of an equilibrium. In both cases, the stochastic output remains the same since it is a profit maximizing solution. The second period consumption (i.e. point C) will be attained by changing the financial portfolio to $\overrightarrow{DC}$.

3.3 Incomplete Financial Markets

If $0 < J < S$, financial markets are called incomplete. The number of independent assets is lower than the number of states of nature and as such the market subspace $\mathbf{M}$ is a proper subset of $\mathbb{R}^S$. In this case, there are consumption vectors $\mathbf{c} \in \mathbb{R}^S \setminus \mathbf{M}$ that can not be replicated by the financial market.

Assuming $W_0 = \partial W(c_0, \mathbf{c}_1)/\partial c_0 > 0$ (i.e. preferences are strictly increasing in the first period consumption), the agent seeks to

$$\max_{\mathbf{z}, \mathbf{h}, \mathbf{c}_1} W(e_0 - c(\mathbf{w}, \mathbf{z}) - \mathbf{v}^T \mathbf{h} + (1 - \delta)p, \mathbf{c}_1) + \lambda^T(\mathbf{A}\mathbf{h} + \mathbf{z} + \delta p \mathbf{1}^S - \mathbf{c}_1) \tag{5}$$

First order conditions:

$(\mathbf{c}_1) : \bigtriangledown_{\mathbf{c}_1} W(c_0, \mathbf{c}_1) - \lambda \leq 0, \ \mathbf{c}_1 \geq 0$

$(\mathbf{h}) : \mathbf{v} = \mathbf{A}^T \dfrac{\lambda}{W_0}$, assuming frictionless incomplete financial markets

$(\mathbf{z}) : -W_0 \bigtriangledown_{\mathbf{z}} c(\mathbf{w}, \mathbf{z}) + \lambda \leq 0, \ \mathbf{z} \geq 0$

$(\lambda) : \mathbf{c}_1 - (\mathbf{z} + \mathbf{A}\mathbf{h}) \leq 0, \ \lambda \geq 0$

Equations $(\mathbf{h})$ represent the first order conditions that characterized the agent participation in financial markets (the financial markets profit maximization conditions). Observe, that $(\mathbf{h})$ is a system of J linear equations in $\mathbf{S}$ unknowns represented by the vector

λ, where λ/W_0 denotes the vector of present-value prices (state-claim prices, stochastic discount factor, price kernel). In general, underdetermined linear systems are consistent, in which case they have infinitely many solutions. Let Λ be the set of solutions to the linear system ($\mathbf{h}$),

$$\Lambda = \left\{ \lambda \in \mathbb{R}^S : \mathbf{v} = \mathbf{A}^T \frac{\lambda}{W_0} \right\}$$

Λ is also the set of no-arbitrage prices. If we restrict attention to strictly monotonic preferences, it follows that the utility gradient $\nabla_{c_1} W(c_0, \mathbf{c}_1) \in \Lambda$, which implies $\nabla_{c_1} W(c_0, \mathbf{c}_1)/W_0$ is the agent's internal stochastic discount factor (i.e. in equilibrium, in general, it will vary from individual to individual).

[Figure 5 inserted here]

Figure 5 shows the farmers decisions in the presence of incomplete financial markets under different subsidy payments schedules (i.e. $\delta = 1$ and $\delta = 0$). Let the optimal consumption vector in the absence of the subsidy be at the point A. The incomplete market is represented by one Arrow security (i.e. the one parallel to the horizontal axis). Because financial markets are incomplete, not all stochastic consumption vectors can be replicated, or priced, in the market. Furthermore, there are stochastic consumption bundles which are priced by agents using internal prices (i.e. prices derived from their risk preferences). Denote $\overrightarrow{OB}$ the optimal production choice in the absence of the subsidy. The farmer will attain the stochastic consumption A, by producing $\overrightarrow{OB}$ and acquiring the portfolio $\overrightarrow{BA}$ (i.e. parallel to the horizontal axis). In this picture, the agent can use the incomplete financial markets only to move parallel to the horizontal axis. The lack of independent financial assets (i.e. a second Arrow security) prevents the farmer from using financial markets to attain stochastic vectors which are not parallel to the horizontal axis.

Suppose the farmer receives a subsidy, assumed to be paid in the first period, and let the point C be the new second period stochastic consumption. Since markets are

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incomplete, the only portfolio choice available to the agents is $\overrightarrow{DC}$. In order to attain the second period stochastic consumption, the farmer will produce $\overrightarrow{OD}$. If the payments are delayed (i.e. $\delta = 0$), the farmer receives the subsidy (i.e. $\overrightarrow{FD}$) in the second period. In order to attain the second period stochastic consumption, the farmer will produce $\overrightarrow{OF}$.

If the residual optimal consumption $\mathbf{c}_1^\star - \delta p \mathbf{1}^S \in M + Z^\star$, the consumption can be replicated using a mix of financial markets and production technology under the no arbitrage price induced by financial markets. In words, this says that the consumption and production (financial and production technology) decisions are separated. The agent acts to maximize his utility from consumption over period 0 and 1, while maximizing profits obtained from financial and agricultural markets using the no arbitrage price of financial markets. A consequence of this separation is that subsidy is decoupled from farmer's decisions productions. To see this note that $\mathbf{c}_1 - \delta p \mathbf{1}^S \in M + Z^\star$ means there are portfolio $h \in \mathbf{R}^J$ and stochastic output $\mathbf{z}$ s.t. $\mathbf{c}_1 - \delta p \mathbf{1}^S = \mathbf{z} + \mathbf{A}\mathbf{h}$ for all states of nature (i.e. the equality is required to hold for all state of nature). In this case, the optimal financial portfolio $\mathbf{h}$ conditional on second period optimal consumption $\mathbf{c}_1^\star$ and stochastic output $\mathbf{z}$ is

$$\mathbf{h}_{|c_1,z_1}^\star = (\mathbf{A}^T\mathbf{A})^{-1}\mathbf{A}^T(\mathbf{c}_1 - \delta p \mathbf{1}^S - \mathbf{z})$$

Substitute $\mathbf{h}_{|c_1,z_1}^\star$ in problem (5) which becomes

$$\max_{\mathbf{z},\mathbf{c}_1} W(e_0 + q(\mathbf{v})^T\mathbf{z} - c(\mathbf{w},\mathbf{z}) - q(\mathbf{v})^T\mathbf{c}_1 + p(1 - \delta + \delta q(\mathbf{v})^T\mathbf{1}^S), \mathbf{c}_1) \qquad (6)$$

where $q(\mathbf{v}) = \mathbf{v}^T(\mathbf{A}^T\mathbf{A})^{-1}\mathbf{A}^T \in \mathbb{R}^S$ is the stochastic discount factor induced by financial markets. Assuming interior solutions for the optimal stochastic output $\mathbf{z}$ and optimal $\mathbf{c}_1$, first order conditions are:

$$\nabla_z c(\mathbf{w},\mathbf{z}) = q(\mathbf{v}) \qquad (7)$$

$$q(\mathbf{v}) = \frac{\nabla_{c_1} W(c, \mathbf{c}_1)}{W_0} \qquad (8)$$

The system of equations (7) and (8) illustrate the separation between production and consumption in incomplete financial markets. Conditions (7) say that under separability from consumption, the optimal stochastic output is the solution to the profit maximization

$$\Pi(\mathbf{w}, q(\mathbf{v})) = \max_{z} \left\{ q(\mathbf{v})^T \mathbf{z} - c(\mathbf{w}, \mathbf{z}) \right\} \qquad (9)$$

At the margin, the extra unit of production is priced by financial markets. Since the farmer chooses the optimal stochastic output as the solution to a profit maximization under the price induced by the markets, his production decisions are decoupled from subsidy. Furthermore, all agents, independent of their risk preferences, agree to price any consumption in $M + Z^\star$ using the price $q(\mathbf{v})$, the claim price vector that eliminates arbitrages. The agreement over the stochastic discount factor is showed by (8), where the farmer's internal claim price vector, represented by utility gradient divided by marginal utility of consumption in the first period, equals the price kernel induced by financial markets.

3.4 Separation Results

It is natural to ask under what conditions the risk averse farmer separates production decisions from consumption decisions in the presence of incomplete financial markets, and as such, effectively removes the link between production and subsidy.

Let $Z^\star = \{\mathbf{z} : \mathbf{z} \in \text{argmax}\{\mathbf{q}(\mathbf{v})\mathbf{z} - c(\mathbf{w}, \mathbf{z})\}\}$ be the set of stochastic output vectors that are economically efficient under the $\mathbf{q}(\mathbf{v})$ pricing. Then the following can be stated:

(Result 1) A subsidy is decoupled from production in incomplete financial markets if $\mathbf{c}_1^\star - \delta p \in \mathbf{M} + \mathbf{Z}^\star$.

Any $\mathbf{z} \in \mathbf{Z}^\star$ is the solution to a profit maximization problem under pricing $\mathbf{q}(\mathbf{v})$

induced by financial markets. The choice of $\mathbf{z}$ is comparable with the choice of optimal portfolio $\mathbf{h}$ since the same pricing vector $\mathbf{q}(\mathbf{v})$ is used to evaluate the financial assets. For an equilibrium to exist, the agent must eliminates all the arbitrage opportunities between financial markets and stochastic technologies in the process of replicating the optimal consumption. This is possible due to the common pricing rule $\mathbf{q}(\mathbf{v})$, and the result is known as separation of production from consumption. If the farmer chooses the optimal stochastic output as a solution to profit maximization under the pricing rule induced by financial markets (i.e. separation between consumption and production), then the subsidy is decoupled from production decisions. When separation of production and consumption is possible, the farmer effectively removes any link between subsidy and production.

The simplest separation occurs when the set of economically efficient outputs is a subset of the financial market subspace ($\mathbf{Z}^\star \subseteq \mathbf{M}$). In this case, the optimal stochastic output $\mathbf{z}^\star$ can be entirely replicated by the financial markets ($\mathbf{z}^\star = \mathbf{z}_M^\star$).[10] This type of separation is known as the efficient-set spanning (Chambers & Quiggin, 2009).

Depending on how efficient the production technology is in removing idiosyncratic risk, the separation can occur over sets as small as the market subspace $\mathbf{M}$ or as large as the set addition of $\mathbf{M}$ and $\mathbb{R}_+^S$. This efficiency in removing idiosyncratic risk is contingent on the firm's elasticity of transformatoin between state-contigent outputs along its cost contours.

A condition for separation to occur on sets larger than the financial market subspace $\mathbf{M}$ is that it must be possible to evaluate $z_{M^\perp}^\star$ under the financial pricing rule $\mathbf{q}(\mathbf{v})$. Specifically, $Z^\star = \{\mathbf{z}^\star : \mathbf{z}^\star \in \mathrm{argmax}\{\mathbf{q}(\mathbf{v})z - c(\mathbf{w}, \mathbf{z})\}\} = \{\mathbf{z}_M^\star + \mathbf{z}_{M^\perp}^\star : \mathbf{z}_M^\star + \mathbf{z}_{M^\perp}^\star \in \mathrm{argmax}\{\mathbf{q}(\mathbf{v})\mathbf{z}_M - c(\mathbf{w}, \mathbf{z_M} + \mathbf{z_M^\perp})\}\}$. If $\mathbf{c}_1^\star - (1-\delta)s \in \mathbf{M} + \mathbf{Z}^\star$ holds, there is an output vector $\mathbf{z}^\star$ and a portfolio vector $\mathbf{h}^\star$ such that $\mathbf{c}_1^\star - (1-\delta)s = \mathbf{z}^\star + \mathbf{A}\mathbf{h}^\star = \mathbf{z}_M^\star + \mathbf{z}_{M^\perp}^\star + \mathbf{A}\mathbf{h}^\star$. If $\mathbf{z}_{M^\perp}^\star$ can not be priced under $\mathbf{q}(\mathbf{v})$, then $\mathbf{z}_{M^\perp}^\star \notin Z^\star$.

None of the above separation results require that the set of technically feasible state-

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[10]Any vector $\mathbf{z} \in \mathbb{R}_+^S$ can be decomposed such that $\mathbf{z} = \mathbf{z}_M + \mathbf{z}_{M^\perp}$, where $\mathbf{z}_M \in \mathbf{M}$ and $\mathbf{z}_{M^\perp} \in \mathbf{M}^\perp$ (the orthogonal complement of $\mathbf{M}$).

contingent outputs ($Z = \cup_{\mathbf{x}}\{\mathbf{z} : \mathbf{x} \in X(\mathbf{z})\}$) be a subset of the market subset (i.e. $Z \subseteq \mathbf{M}$).

[Figure 6 inserted here]

Figure 6 shows separability between consumption and production decisions (i.e. z), when the stochastic output vector z is not replicable in financial markets. In this case, the incomplete financial markets are represented by the M and the price induced by the markets by $q(\mathbf{v})$. Since the stochastic output vector $\overrightarrow{0\mathbf{z}}$ is not in M, it cannot be replicated in the financial markets. There is no portfolio $h \in \mathbb{R}_+^J$ s.t. $\mathbf{z} = \mathbf{A}h$. However, the production vector $\mathbf{z}$ is determined based on the stochastic discount factor $q(\mathbf{v})$ induced by M and separation occurs.

[Figure 7 inserted here]

Figure 7 shows the separation result in incomplete financial markets when the subsidy is paid in the first period. Let the optimal consumption vector in the absence of the subsidy be at the point A. Denote $\overrightarrow{OB}$ the optimal production choice in the absence of the subsidy. The farmer will attain the stochastic consumption A, by producing $\overrightarrow{OB}$ and acquiring the portfolio $\overrightarrow{BA}$. Let the point C be the new second period stochastic consumption in the presence of the subsidy paid in the first period. The consumption $\overrightarrow{OC}$ is replicable in financial markets ($\overrightarrow{OC} \in \mathbf{M}$) and as such the optimal choice of stochastic output will also be replicable in financial markets. The vector $\overrightarrow{OD}$ (i.e. the optimal stochastic output) is a solution to the profit maximization under the pricing rule induced under $\mathbf{M}$.

[Figure 8 inserted here]

Figure 8 shows the separation result in incomplete financial markets when the subsidy is paid in the second period. The intuition is the same as in Figure 7 with the observation

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that in this case there are delays in the subsidy payments.

(Corollary 2) A subsidy is decoupled from production if the optimal stochastic consumption of the second period lies completely in the span formed by existing financial assets.

In this case, the agricultural technology is either redundant, if $\mathbf{Z}^\star \subset \mathbf{M}$, or the agent is not farming $\mathbf{Z}^\star \cap \mathbf{M} = \emptyset$

The optimal stochastic output $\mathbf{z}^\star$ can be decomposed into two orthogonal components $\mathbf{z}_M^\star$ and $\mathbf{z}_{M^\perp}^\star$. Since $\mathbf{z}_M^\star$ is the solution to a profit maximization problem, it is decoupled from the subsidy payments. On the other hand, $\mathbf{z}_{M^\perp}^\star$ has the potential to be linked to the subsidy (i.e. when separability between consumption and production fails).

(Result 3) The degree of decoupling of the subsidy from production is non decreasing in the dimension of the financial market subspace $\mathbf{M}$.

Let $\mathbf{a} \in \mathbb{R}^S$ be a new financial asset that is independent of the existing J assets (i.e. $\mathbf{A}^T \mathbf{a} = 0$), v_a is the price of $\mathbf{a}$ and h_a is the amount of asset $\mathbf{a}$ purchased or sold by the farmer. The model can be written as:

$$\min_{\mathbf{z},\mathbf{h},\mathbf{h_a}} \{c(\mathbf{w},\mathbf{z}) + \mathbf{v}^T\mathbf{h} + v_a h_a : \mathbf{z} + \mathbf{A}\mathbf{h} + \mathbf{a} \geq \mathbf{c_1^\star} - \delta p \mathbf{1}^S\} \tag{10}$$

Solving for the optimal stochastic output $\mathbf{z}_{M^\perp}$, we have

$$\mathbf{z}_{M^\perp} = c_{M^\perp}^\star - \mathbf{a}h_a \tag{11}$$

which can be further decomposed into the vector of consumption that is replicable by the asset $\mathbf{a}$ and its orthogonal complement. In other words, $\mathbf{z}_{M^\perp} = \mathbf{z}_{M^\perp a} + \mathbf{z}_{M^\perp a^T}$, where $\mathbf{z}_{M^\perp a}$ can be replicated by the new asset $\mathbf{a}$ and $\mathbf{z}_{M^\perp a^\perp}$ is in the left null space of $\mathbf{a}$. Observe that

$\mathbf{z}_{M^\perp a}$ and $\mathbf{z}_{M^\perp} a^\perp$ are orthogonal to each other, and both are orthogonal to the range of payoff matrix $\mathbf{A}$ (i.e. the financial market subspace $\mathbf{M}$). By nonnegativity of stochastic output, it follows that $\mathbf{z}_{M^\perp} \geq \mathbf{z}_{M^\perp a^\perp}$. Since $\mathbf{a}$ is linearly independent of other assets that form the column space of $\mathbf{A}$, it will increase the dimension of the financial market subspace. The dimension of the newly market subspace $\mathbf{M}_a = \{\mathbf{y} : \mathbf{y} = \mathbf{Ah} + \mathbf{a}h_a\}$ is $\dim(\mathbf{M}_a) = \dim(\mathbf{M}) + \dim(\mathbf{a}) = J + 1 > J = \dim(\mathbf{M})$.

3.5 Non Separation Results

Suppose the farmer's stochastic discount factor

$$\frac{\nabla_{c_1} W(c, \mathbf{c}_1)}{W_0} \in \Lambda \setminus \left\{q(\mathbf{v})\right\}$$

Then the farmers internal claim state prices vector differs from the stochastic discount of the financial market and for at least a state of nature the residual consumption $c_s - (1-\delta)p \notin M + Z^\star$. In words, production decisions and consumption are not separated. However, under certain conditions, subsidies continue to be decoupled from production decisions even in the absence of separation between production and consumption.

(**Result 4**) If preferences over consumption $(c_0, \mathbf{c}_1)$ are translated homothetic in the direction of $g = ((1-\delta)p, \delta p, \dots, \delta p)$, the subsidy is decoupled from production decisions.

Let $(c_0^\star, \mathbf{c}_1^\star)$ be the optimal consumption in the presence of the subsidy and $(c_0, \mathbf{c}_1)$ be the optimal consumption in the absence of the subsidy. If $\nabla_{(c_0, \mathbf{c}_1)} W(c_0^\star, \mathbf{c}_1^\star) = \alpha \nabla_{(c_0, \mathbf{c}_1)} W(c_0, \mathbf{c}_1)$, then

$$\frac{\nabla_{\mathbf{c}_1} W(c_0^\star, \mathbf{c}_1^\star)}{W_{c_0}(c_0^\star, \mathbf{c}_1^\star)} = \frac{\nabla_{\mathbf{c}_1} W(c_0, \mathbf{c}_1)}{W_{c_0}(c_0, \mathbf{c}_1)} = \nabla_{\mathbf{z}} c(w, \mathbf{z})$$

which says that the agent will use the same pricing rule to find the optimal production vector $\mathbf{z}$ in the presence and absence of subsidy. Furthermore, from the first order conditions, it can be shown that $(c_0^\star, \mathbf{c}_1^\star) = (c_0, \mathbf{c}_1) + ((1-\delta)p, \delta p, \dots, \delta p)$.

(Corollary 5) If preferences are quasi-homothetic in the direction of $g = (\delta p, \ldots, \delta p)$, the subsidy is decoupled from production decisions.

[Figure 9 inserted here]

Figure 9 shows how the subsidy can be decoupled from production decisions in the absence of separation between production and consumption. The lack of separation means that the agent will use an internal discount factor which is different than the market kernel (i.e. the discount factor induced by the financial markets). As such, the production decisions of the agent are not independent of agent's preferences for consumption. However, since agent preferences are homothetic in the direction of the subsidy, the internal discount factor of the agent will not change with the introduction of the subsidy. This implies that neither will his production decisions.

4   Conclusion

This paper contributes to the decoupled subsidies literature by identifying mechanisms through which production decisions of risk averse agents can be decoupled from agricultural subsidies. Ignoring the roles played by incomplete financial markets and the timing of subsidy payments causes the production distortions induced by the subsidy in the case of farmers facing stochastic technologies and stochastic markets to be overstated. I present conditions that ensure the subsidy is decoupled from production in the presence of incomplete financial markets under the pricing rule induced by the market. This amounts to showing how farmers with different risk preferences, but the same technology, make the same production decisions over consumption sets where separation induced by financial markets holds. Second, conditional on farmers' ability to transfer consumption across time, which itself depends on financial markets' potential to replicate uncertain consumption, the timing of subsidy payments may affect the size of production distortions.

In effect, a subsidy coupled via the indirect mechanisms identified by the literature becomes decoupled from production due to the separation induced in incomplete financial markets. These findings help reconcile some of previous theoretical findings with the empirical evidence.

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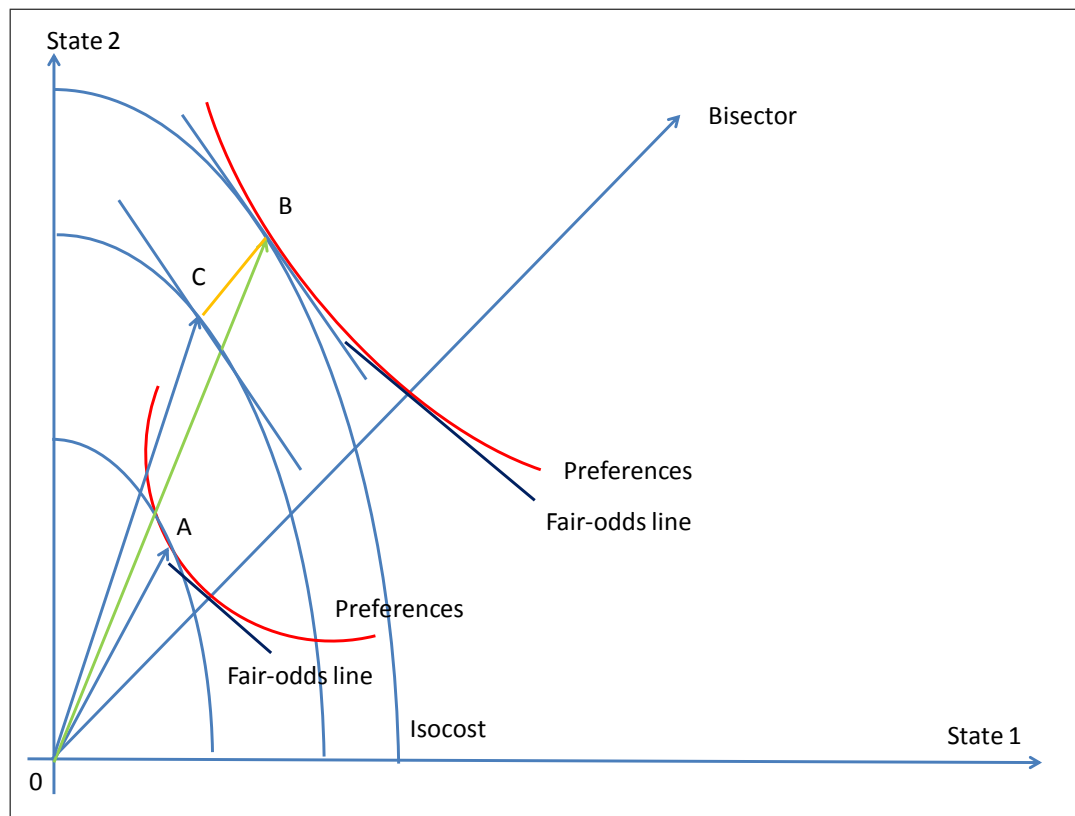
5 Appendix

Figure 1: Production Decisions in the Absence of Financial Markets
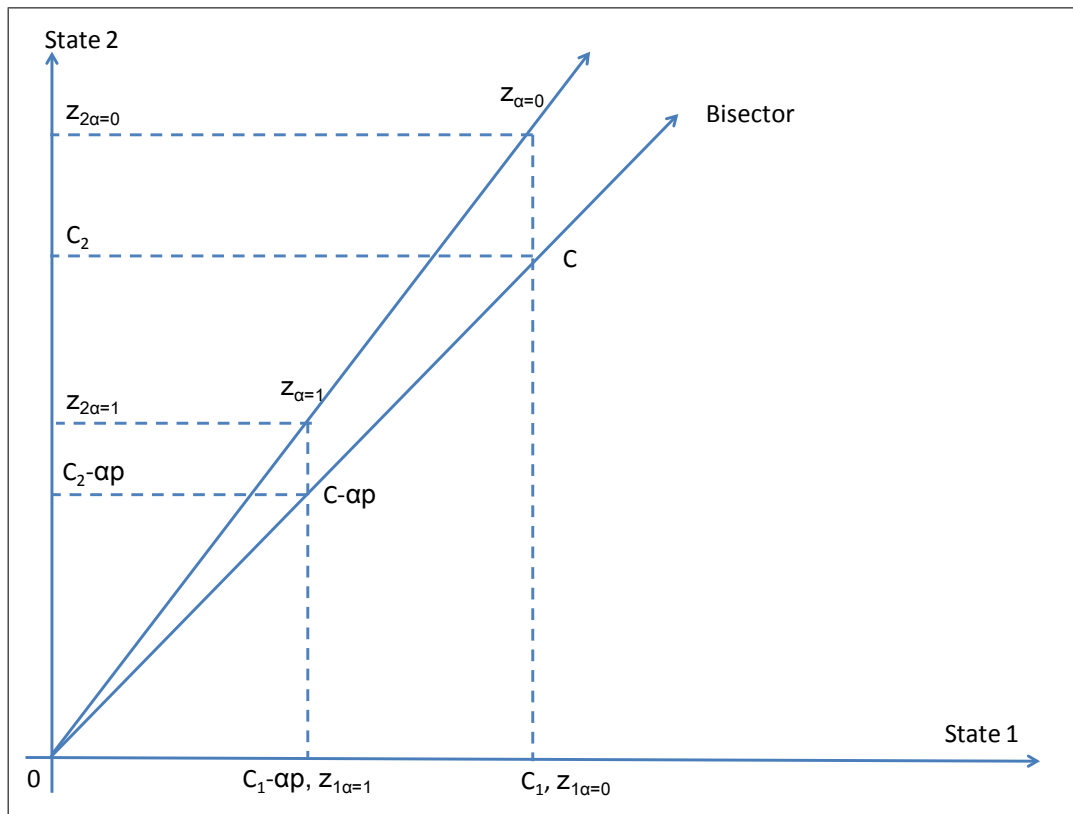
Figure 2: Stochastic Output that Dominates Sure Consumption
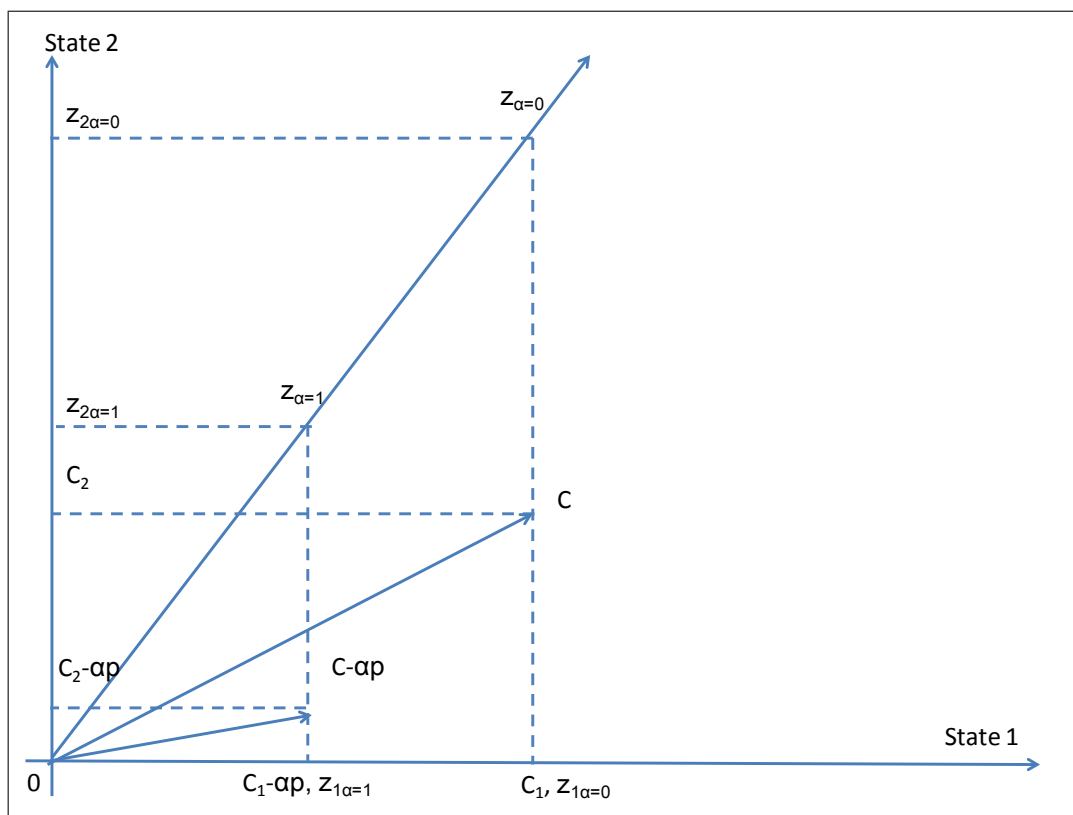

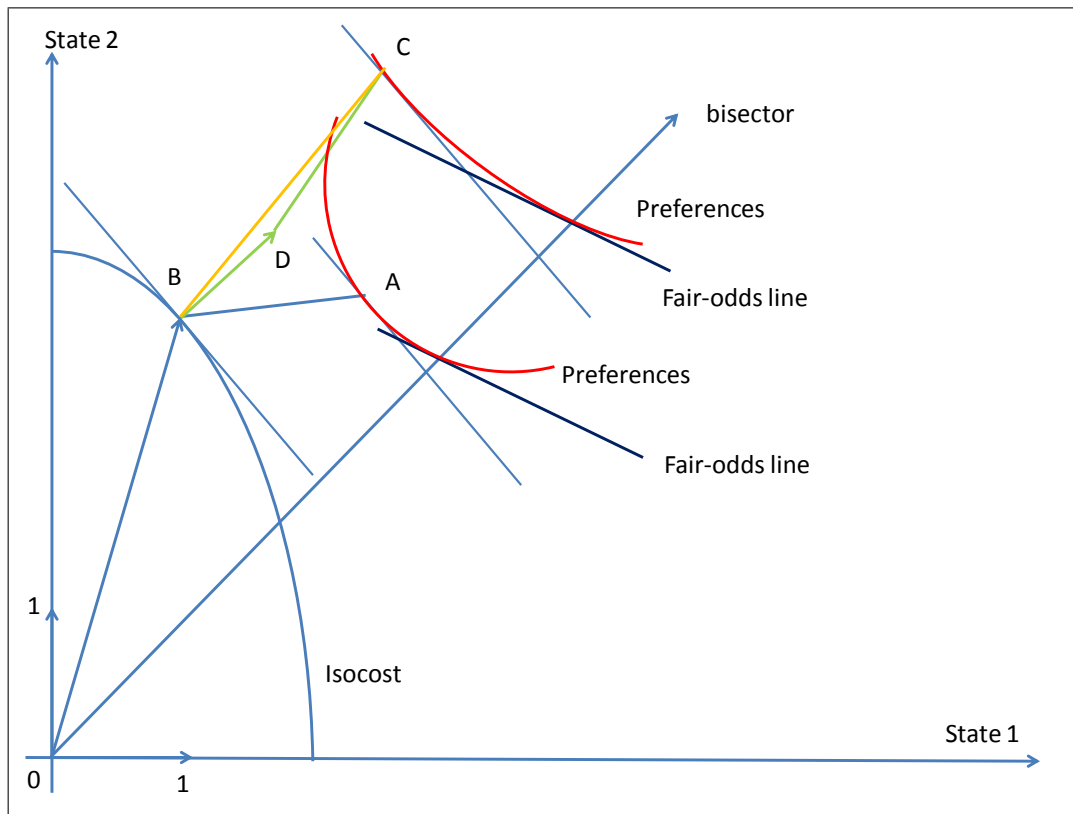Figure 3: Stochastic Output that Dominates Stochastic Consumption

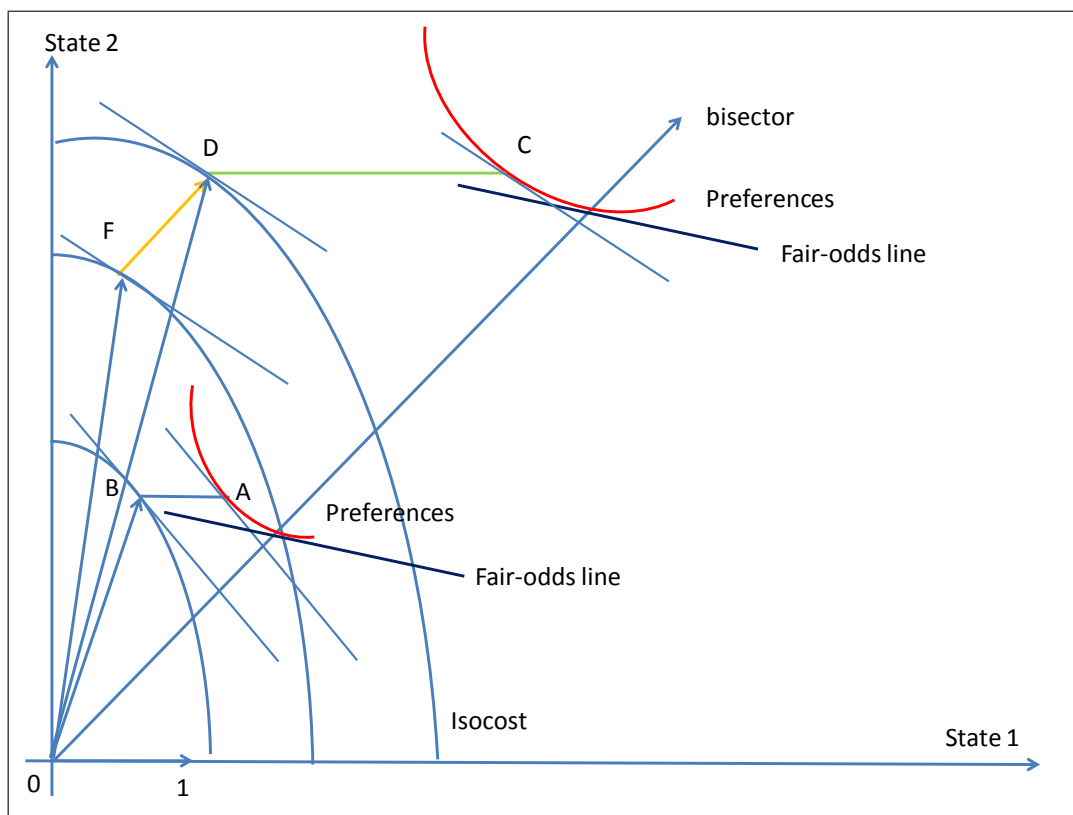Figure 4: Production Decisions in Complete Financial Markets

Figure 5: Production Decisions in Incomplete Financial Markets

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Figure 6: Separability when Stochastic Output Is Not Replicable in M

Figure 7: Decoupled Subsidies in Incomplete Financial Markets with $\delta = 0$

Figure 8: Decoupled Subsidies in Incomplete Financial Markets with $\delta = 1$

Figure 9: Decoupled Subsidies when Separation Does not Hold