

# The Efficiency of Direct Payments versus Tax Reductions under Uncertainty\*

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## Abstract

This paper analyzes the optimal behavior of farmers in the presence of direct payments and uncertainty. In an empirical analysis for Switzerland, it confirms previously obtained theoretical results and determines the magnitude of the theoretical predicted effects. The results show that direct payments increase agricultural production between 3.7% to 4.8%. Alternatively to direct payments, the production effect of tax reductions is evaluated in order to determine its magnitude. The empirical analysis corroborates the theoretical results of the literature and demonstrates that tax reductions are also distorting, but to a substantially lesser degree if losses are not offset. However, tax reductions, independently whether losses are offset or not, lead to higher government spending than pure direct payments.

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# 1 Introduction

Agricultural policy reforms such as the Agenda 2000 in Europe or the U.S. Farm Act 1996 promoted direct payments, either as green direct payments or as compensatory payments as a means of income support for farmers. Previous income support for farmers was based on price supports for different commodities, but was found to be inefficient and not adequate for responding to the challenges agriculture will face in the next millennium.

The OECD (1995) distinguishes between "pure" direct payments and "less economically distorting direct payments", commonly referred to as decoupled or coupled direct payments, respectively. The former category is unrelated to past and future levels of output and factors of production as well as present levels and free of any conditions or constraint on recipients. The latter category includes measures that imposes conditions on recipients or may be linked to inputs, output or income levels, providing they are nearly neutral with respect to current and future production levels. Decoupled payments under environmental or regional assistance programs, or for income support, are classified as green box measures by the WTO Agreement within the Uruguay Round (WTO, 2000). Green box measures however, need not to be included in the calculation of the Total Aggregate Measurement Support (Total AMS), and are exempt from the agreed reduction of 20%. As such they have a specific appeal to policy makers.

The majority of direct income measures, implemented in the OCED member countries fall in the category of coupled direct payments in order to stabilize and/or to provide income. As such, they have a distorting effect on production. However, the literature also identifies problems with decoupled direct payments in the context of a stochastic environment. Sandmo (1971), and Pope and Just (1991) showed that decoupled direct payments, having a pure wealth effect, will not alter production decision if preferences are CARA (Constant Absolute Risk Aversion). If direct payments were stochastically independent from farm profits (the profits exclusively obtained from farming), direct payments would induce a pure wealth effect and consequently lead to a change in production decisions for preferences other than CARA. Production would rise with an increase in pure wealth if preferences were DARA (Decreasing Absolute Risk Aversion) or it would decrease with an increase in pure wealth if preferences were IARA (Increasing Absolute Risk Aversion). For a stochastic environment, however, decoupled support often does not present a pure wealth effect because the farm profits and the magnitude of direct payments are stochastically dependent, e.g. by the weather or the market price. For this case,

Hennessy (1998) establishes sufficient conditions, where an increase or decrease in decoupled direct payments increases or decreases production respectively.

This paper provides an empirical application of the theory of the farmer's behavior under uncertainty in the presence of decoupled green direct payments in exchange for the provision of environmental public goods, or the production of positive externalities. We compare our results, obtained for the case of Switzerland, to the results of an empirical analysis for Iowa conducted by Hennessy (1998). This paper extends Hennessy's previous work to the case where market price and crop yields are correlated, i.e. the case of a locally traded good or a small country with no free trade. Additionally, the Swiss direct green payment scheme as it is currently in place presents the additional element of income support and income stabilization at the same time.

Finally, and most importantly, we analyze the effect of tax reductions on farm profits in exchange for the provision of environmental public goods, or the production of positive externalities. In contrary to the case of certainty where tax reductions do not affect the optimal level of output, Sandmo (1971) showed that this result does not hold in the case of uncertainty. However, the presented analytical results, obtained for the special case of full loss offset do show to which extent a tax reduction distorts the optimal output level. To answer this question an empirical analysis is proposed. Moreover, this empirical analysis allows to compare the distorting impact of direct payments and tax reductions. In this way it may guide policy makers to define policies with the least distorting impact.

## 2 Direct Payments

Hennessy (1998) has shown that even decoupled direct payments alter production decisions in the context of a stochastic environment. To quantify the magnitude of this distortion, we analyze the effect of decoupled direct payments as they are paid in Switzerland according to the Swiss Farm Bill 2000, Article 31b. As an example we consider the case of wheat, where farmers receive direct payments provided that they follow certain guidelines for its production. Moreover, the price of wheat is guaranteed up to a certain level of the national production. Once the national production exceeds this amount the target price is not supported anymore, and farmers face a negatively sloped, but still government supported, demand curve. Thus, the government provides income support and income stabilization. Additionally, our statistical analysis shows that there is a strong correlation between the individual

crop yields at the farm level and the nationally produced amount of wheat. Thus, the farmer's crop yield is not independent of the market price, due to a government price scheme that is based on the amount of the nationally produced wheat. This setting captures the case of locally traded goods or the case of a small country with no free trade with the rest of the world.

## 2.1 Empirical Analysis

The Swiss agricultural classification schemes for agricultural production distinguishes between 6 different zones. Our empirical analysis represents a farm located in a region classified as a valley zone. Based on a typical wheat production function for this region (Walter, 1994) and the cultivation techniques and fertilization rates proposed by the extension services, we estimated the mean wheat yield per hectare at the farm level,  $\mu_F$ , and the cost function,  $C(x)$ , where  $x$  denotes wheat yields. Based on a risk analysis for the Swiss wheat production by Regev, Gotsch and Rieder (1997) we calculated the standard deviation of the wheat yields at farm level,  $\sigma_F$  that corresponds to the previously determined  $\mu_F$ . Additionally, we estimated the mean and the standard deviation the nationally produced wheat yields per hectare, denoted by  $\mu_{CH}$  and  $\sigma_{CH}$  respectively, based on data collected by the SBS (1970-1999). The results of our estimation are presented in Table 1.

	Farm Level	National Level
Mean crop yield	$\mu_F = 56.98$ dt/ha	$\mu_{CH} = 59.03$ dt/ha
Std. dev. of crop yield	$\sigma_F = \pm 9.04$ dt/ha	$\sigma_{CH} = 4.736$ dt/ha
Cost Function	$C(x) = 2378 + 2.2852 \cdot \exp(0.00786)x$	—

Table 1: The Production Environment

Moreover, we estimated the changes in  $\sigma_F$  as a result of a change in  $\mu_F$ . Based on the risk analysis by Regev, Gotsch and Rieder (1997), we obtained the following results presented in Table 2.

$\mu_F$	34.531	41.432	46.069	50.299	54.528	58.758	62.871	67.216	68.516	69.716	70.445
$\sigma_F$	7.513	7.827	8.079	8.617	9.203	10.066	11.046	12.698	13.573	14.380	15.544

Table 2: Changes in  $\sigma_F$  as a result of a change in  $\mu_F$  in dt/ha

The government supported demand function  $q$  for wheat for the years 1995 and 1996 was calculated based on data supplied by the SBS (1970-1999), which provides the inverse demand function expressed in terms of one hectare: <sup>1</sup>

$$p(q) = \begin{cases} \frac{151.322-q}{1.285}, & q > 39dt \\ 87.4105, & q \leq 39dt. \end{cases}$$

Farm profits per hectare  $\pi(x)$  can be calculated by  $\pi(x) = p(q)x - C(x)$ , where  $q$  and  $x$  are both stochastic. It is assumed that  $x$  and  $q$  are normally distributed with parameters  $(\mu_F, \sigma_F)$  and  $(\mu_{CH}, \sigma_{CH})$  respectively. <sup>2</sup> However  $x$  and  $q$  are not independent. Their linear dependency, expressed as the correlation coefficient  $r$ , was estimated based on the central evaluation of the accounting data for Swiss farms (FAT, 1987-1996). The value was found to be 0.63. Hence, they were modelled as a bivariate normal distribution taking into account the value of  $r$ . <sup>3</sup>

The employed utility function is quite flexible and allows us to accommodate CARA and DARA preferences<sup>4</sup>. For brevity of exposition, however, we limit our discussion to the case of DARA preferences since they are widely supported by the empirical literature (Binswanger, 1981; and Chavas and Holt, 1990).

The utility function is given by

$$U(\pi) = -\exp(-\gamma_1\pi) + \gamma_2\pi,$$

for  $\gamma_1, \gamma_2 > 0$ , and all  $\pi$  (Lin and Chang, 1978), and its coefficient of absolute risk aversion by

$$\rho(\pi) = \frac{\gamma_1^2 \exp(-\gamma_1\pi)}{\gamma_1 \exp(-\gamma_1\pi) + \gamma_2}.$$

The parameters of the utility function are calibrated with the help of  $\theta(\pi)$ , the risk premium at farm profit level  $\pi$ . The risk premium denotes the fraction of the

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<sup>1</sup>The analysis does not incorporate years previous to 1995, since there were changes in the government support programme.

<sup>2</sup>Our data did not provide evidence of non-symmetry so that the assumption of a normal distribution seems appropriate.

<sup>3</sup>In order to obtain the desired linear dependency between the stochastic variables  $x$  and  $q$ , they were generated according to  $x = \sigma_F z_1 + \mu_F$  and  $y = a_1 z_1 + a_2 z_2 + \mu_{CH}$ , where  $a_1 = 0.63 \sigma_{CH}$ ,  $a_2 = \sqrt{\sigma_{CH}^2 - (a_1)^2}$  and  $z_1, z_2$  are normal distributed variables with mean 0 and standard deviation 1.

<sup>4</sup>More flexible utility specification, such as the expo-power function of Saha (1993), have been developed, however, it is often not quite clear how the choice of the parameter values relate to risk aversion attributes (Hennessy, (1998)).

standard deviation of an equiprobable two-point gamble that a risk-averse person would be willing to pay to avoid the gamble. Thus, we obtain:

$$\theta(\pi) = \frac{E(\pi) - U^{-1} \left[ \frac{1}{2}U(\pi + \sigma_\pi) + \frac{1}{2}U(\pi - \sigma_\pi) \right]}{\sigma_\pi}, \quad (1)$$

where the two point gamble is in terms of  $\pm\sigma_\pi$ . To compare our result to those of Hennessy we also choose  $\theta(0) = 0.5$  and  $\theta(E(\pi)) = 0.25$ . Utilizing the two values of  $\theta(\cdot)$  equation (1) can be solved for the values of  $U^{-1}[\cdot]$  - the certainty equivalents  $CE_1$  and  $CE_2$ . Thus the following  $i$  equations,  $i = 1, 2$  have to hold:

$$\frac{1}{2}U(\pi_i + \sigma_\pi) + \frac{1}{2}U(\pi_i - \sigma_\pi) = U[CE_i], \quad i = 1, 2, \quad (2)$$

where  $\pi_1 = E(\pi)$  and  $\pi_2 = 0$ . The two equations were solved numerically in order to specify the parameters  $\gamma_1$  and  $\gamma_2$  of the utility function  $U$ . The results are presented in Table 3.

$\gamma_1$	$\gamma_2$	$\theta(\pi = 0)$	$\theta(\pi = \pi')$	$\rho(\pi = 0)$	$\rho(\pi = \pi')$
0.002476680	0.000381477	0.5	0.25	0.00214612	0.00080626

Table 3: Parameters and Risk Attitudes

## 2.2 Simulation

Based on the data presented in Tables 1 - 3 we simulated for each of the eleven pairs of  $\mu_F$  and  $\sigma_F$  (Table 2) 30000 wheat yields per hectare. The high number of drawings ensured that the mean and standard deviation of the simulated values settled on the prespecified values. The obtained results allowed us to calculate the associated profits per hectare and the corresponding utility. We assumed that producers maximize their expected utility derived from the profits of agricultural production. The farmers choice variable is  $\mu_F$ , i.e. the intensity of production. Higher expected yields, however, are only obtained at the cost of high risk, i.e., an increase in  $\sigma_F$ .

To evaluate the impact of direct payments on the production intensity we added 500, 1000, 2000 and 5000 Swiss Francs to the farm profits per hectare. The altered values of the farm profits per hectare translate into different values of utility, and therefore the maximization of the expected utility may lead to the choice of a different production intensity. The outcome of these calculations is presented in Table 4.

Direct payment	Optimal intensity (*)	Farm profits	Farm profits plus direct payments
0	67.217 dt (0%)	1820.19	1820.19
500	69.717 dt (3.7%)	1820.19 + 74.91 = 1895.10	1895.10 + 500.00 = 2395.10
1000	69.717 dt (3.7%)	1820.19 + 74.91 = 1895.10	1895.10 + 1000.00 = 2895.10
1500	70.446 dt (4.8%)	1820.19 + 93.04 = 1913.23	1913.23 + 1500.00 = 3413.23
2000	70.446 dt (4.8%)	1820.19 + 93.04 = 1913.23	1913.23 + 2000.00 = 3913.23
5000	70.446 dt (4.8%)	1820.19 + 93.04 = 1913.23	1913.23 + 5000.00 = 6913.23

(\*) The values in brackets indicate the increase in production in percent as a result of direct payments.

Table 4: Optimal Intensity as a Function of Direct Payments

The results show that direct payments, as they are in place in Switzerland, enhances the optimal production intensity of a risk-averse producer by the magnitude of approximately 4,25%. However, the intensity effect decrease as direct payments increase. The first 500 Swiss Francs leads to an increase in production that increases profits beyond the amount of the direct payment by 74.91 CHF (distortion effect). Thereafter, the distortion effect is decreasing with an increase in direct payments to 18.13 CHF ( $74.91 + 18.13 = 93.04$ ) and then to 0 CHF. In accordance with the definition used by Hennessy (1998), the Swiss direct payment scheme can be considered as decoupled since the governmental price support does not depend on the farmers' output. Yet, they are linked stochastically. A comparison of our results with those of Hennessy, obtained for corn production in Iowa, confirms the production intensification effect of decoupled direct payment, and shows that this effect is even stronger for the case of wheat production in Switzerland, i.e. 4.8% versus 2.75% .

### 3 Tax Reductions on Farm Profits

A well established result in the theory of the firm is that a change in a proportional rate of profit taxation will have no effect on the level of output. In line with this result one could think of green tax reductions  $\tau$  on farm profits in exchange for the provision of environmental public goods or the production of positive externalities. However, Sandmo (1971) has shown that this result does not hold in the presence of uncertainty and the level of output varies with a change in the tax rate. For the case where the farm can always compensate losses of one activity with gains of

another activity such that it never experience a loss (full loss offset), Sandmo (1971) demonstrated that an increase in the tax rate will increase, leave constant or reduce output according as relative risk aversion is increasing, constant, or decreasing.

While the theoretical results of the effect of direct payments or tax reductions on the level of output are interesting, they do not allow to estimate the magnitude of this effect. In particular they do not allow comparing the effect of these two policies. For this purpose we complement our empirical study by calculating the change in output as a result of a reduction in the tax rate. However, we do not consider the limited case of full loss offset considered by Sandmo (1971), since this situation is not typical for agricultural firms. However, we distinguish between two situations, In the first case (partial loss offset) farmers receive a subsidy that compensates in part for their losses. Hence, they may experience profit losses. The amount of the subsidy corresponds to the product  $-\pi\tau$ , for  $\pi < 0$ . In the second case (no loss offset) farmers receive tax reductions only for the case where farm profits are positive. In order to compare direct payments and tax rate reductions the latter one was chosen such that it equals a direct payment of 500, 1000, 1500, 2000 and 5000 CHF. For instance a direct payment of 500 CHF requires a tax reduction of 0.275 of the average farm profits obtained with no government support (1820.19 CHF). The tax reductions corresponding to the direct payments of 1000, 1500, 2000 and 5000 were calculated likewise and are presented in Tables 5 (partial loss offset) and 6 (no loss offset). The results show that tax reductions, in contrary to the first intuition, are equally distorting than direct payments. Yet, tax reductions with loss offset are more costly to the government than pure direct payment. For example tax reductions, “equivalent” to direct payments of 500 CHF, lead to government spending of 521.10 CHF. For the case of tax reductions without loss offset we observe however, that they are less distorting than direct payments or tax reductions with loss offset. For the most realistic case of tax reductions equivalent to direct payments of 500 CHF, the distortion effect is even zero if losses are not offset. However, tax reductions without loss offset increases government spending by 0 - 4 % compared to pure direct payments. For the case of tax reductions with loss offset this increase is between 4 - 5 %.



Tax rate reduction	Optimal intensity (*)	Farm profits	Farm profits plus tax reductions
0.000	67.217 dt (0%)	1820.19	1820.19
0.275	69.717 dt (3.7%)	1820.19 + 74.91 = 1895.10	1895.10 + 521.10 = 2416.15
0.550	69.717 dt (3.7%)	1820.19 + 74.91 = 1895.10	1895.10 + 1042.10 = 2937.20
0.825	70.446 dt (4.8%)	1820.19 + 93.04 = 1913.23	1913.23 + 1578.10 = 3491.33
1.099	70.446 dt (4.8%)	1820.19 + 93.04 = 1913.23	1913.23 + 2104.14 = 4017.37
2.749	70.446 dt (4.8%)	1820.19 + 93.04 = 1913.23	1913.23 + 5260.36 = 7173.59

(\*) The values in brackets indicate the increase of the production in percent as a result of tax reductions.

Table 5: Optimal Intensity as a Function of Tax Reductions with Partial Loss Offset

Tax rate reduction	Optimal intensity (*)	Farm profits	Farm profits plus tax reductions
0.000	67.217 dt (0%)	1820.19	1820.19
0.275	67.217 dt (0%)	1820.19 + 0.00 = 1820.19	1820.19 + 500.00 = 2320.19
0.550	68.517 dt (2.1%)	1820.19 + 41.37 = 1861.56	1861.56 + 1023.65 = 2885.21
0.825	68.517 dt (2.1%)	1820.19 + 41.37 = 1861.56	1861.56 + 1535.50 = 3397.06
1.099	68.517 dt (2.1%)	1820.19 + 41.37 = 1861.56	1861.56 + 2047.31 = 3908.87
2.749	69.717 dt (4.8%)	1820.19 + 74.91 = 1895.10	1895.10 + 5210.50 = 7105.60

(\*) The values in brackets indicate the increase of the production in percent as a result of tax reductions.

Table 6: Optimal Intensity as a Function of Tax Reductions with No Loss Offset

## 4 Conclusions

This paper analyzes the optimal behavior of agricultural producers in the presence of direct payments and uncertainty. For the case of Switzerland, it empirically

confirms previous results that even decoupled direct payments intensify agricultural production in the context of a stochastic environment. The intensification effect in Switzerland is even stronger than for the previously analyzed case of Iowa, the magnitude of the overall effect is not large but definitely not negligible. Additionally, we suggest tax reductions as an alternative means of income support or income stabilization in exchange for the provision of environmental public goods. However, only for the case of no loss offset tax reductions lead to a notable reduction in the distortion of production decisions. Tax reductions can be designed in line with the general tax system. For instance, in many countries, tax reductions are offered for families with children. One can think along this line of our proposal of tax reductions for the provision of public goods or the provision of positive externalities.

The previous results are obtained in the context of a single product or activity but do not necessarily hold for the case of a multi-product/activity environment under uncertainty. Determining the production effects within this setting, requires an empirical analysis and is seen as a promising area for future research.

## References

- Binswanger , H., (1981), Attitudes Toward Risk: Theoretical Implications of an Experiment In Rural India, *Economic Journal*, Vol. 91, Dec., 867-890.
- Chavas, J-P. and M. Holt, (1990), Acreage Decisions under Risk: The Case of Corn and Soybeans *American Journal of Agricultural Economics*, Vol. 72, Aug., 529-38.
- FAT (Forschungsanstalt Tänikon). (1987-1996), *Zentrale Auswertung von Buchhaltungsdaten*, Tänikon.
- Hennessy, D., (1998), The Production Effects of Agricultural Income Support Policies Under Uncertainty, *American Journal of Agricultural Economics*, 80, 46-57.
- Lin, W. and H. Chang., (1978), Specification of Bernouillian Utility Functions in Decision Analysis, *Agricultural Economic Research*, 30, 30-36.
- OECD, (1995), *Agricultural Policy Reforms: New Approaches- The Role of Direct Payments*, Paris: <http://www.oecd.org/agr/policy/ag-pol/agpolref.pdf>, (17-10-2000).
- Pope, R. and R. Just, (1991), On Testing the Structure of Risk Preferences in Agricultural Supply Analysis, *American Journal of Agricultural Economics*, 73, 743-748.

Regev, U., N. Gotsch and P. Rieder, (1997), Are Fungicides, Nitrogen and Plant Growth Regulators Risk-Reducing? Empirical Evidence from Swiss Wheat Production, *Journal of Agricultural Economics*, 48, 167-178.

Saha, A., (1993), Expo-Power Utility: A "Flexible" Form for Absolute and Relative Risk Aversion, *American Journal of Agricultural Economics*, 75,,: 905-913.

Sandmo. A., (1971), On the Theory of the Competitive Firm under Price Uncertainty. *American Economic Review*, 61, 65-73.

SBS (Schweizerisches Bauernsekretariat), (1970-1999), *Statistische Erhebungen und Schätzungen*, Brugg.

Walter, U., (1994), *Die Optimierung der Stickstoffdüngung im Ackerbau mit Hilfe der N-Min Methode*, Vol. 1. Eigenössische Forschungsanstalt für landwirtschaftlichen Pflanzenbau, Grangeneuve.

WTO, (2000), *Legal Texts: the WTO Agreements, A Summary of the Final Act of the Uruguay Round*, Geneva: [http://www.wto.org/english/docs\\_e/legal\\_e/ursum\\_e.htm#a](http://www.wto.org/english/docs_e/legal_e/ursum_e.htm#a), (17-10-2000).