On Self-Selection in PES Schemes

Noel Russell[1] and Johannes Sauer[2]

[1]School of Social Sciences, University of Manchester, Manchester M13 9PL, UK, noel.russell@manchester.ac.uk
[2]School of Social Sciences, and Sustainable Consumption Institute, University of Manchester, Manchester M13 9PL, UK, johannes.sauer@manchester.ac.uk

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RESULTS OF PRELIMINARY ANALYSIS: NOT FOR QUOTATION

Abstract

This paper investigates participation by farmers in the UK Environmental Stewardship Schemes and how decisions to join the scheme are related to land productivity levels on the one hand and ecological conservation on the other. In particular the paper will explore the extent to which the self selection of farmers onto the scheme influences likely scheme performance. The first part of the paper analyses a theoretical model for the provision of ecological services where an uninformed government agency offers to contracts to well-informed farmers. The results of this analysis indicate the extent to which self selection by farmers can impair the efficiency of PES schemes and point to specific strategies that might be used by a government agency to mitigate these effects. These results are used to motivate the empirical analysis of a sample of participants in the UK's Environmental Stewardship Schemes (ESS). We use a comprehensive dataset for more than 10,000 ESS agreements over different years to estimate different regression models. The results of this preliminary analysis can inform policy makers on a more adequate design of conservation schemes with respect to positive and/or negative effects of self-selection.

Keywords: Payment for Environmental Services; Self-Selection in PES Schemes; UK Environmental Stewardship Schemes; Beneficial Selection.

1. Introduction

There is now a substantial literature on the design, efficiency and effectiveness of schemes that provide payments to farmers for the provision of ecosystem services on their land. These schemes (often referred to as PES schemes) typically involve the voluntary participation by farmers who can decide how much of their land to enter into the scheme and payment levels are generally set to reflect the opportunity costs of providing specific services on this land. An important issue here is the problem of asymmetric information where the farmers receiving the payments have better information than the agency providing the payments about both the level of services that can be provided on their land and the opportunity costs of providing these services.

This problem has been highlighted by a large number of studies and there is widespread belief that the outcome in many circumstances is characterised by impaired scheme efficiency. It has been examined from a contract design perspective by Ferraro (2008), Wu and Babcock (1996), Moxey et al. (1999) (and others), and from a more specific spatial targeting perspective by Canton et al. (2009) and Khanna and Ando (2009). These studies highlight the problem of information asymmetry and suggest a variety of strategies the agency might adopt to ameliorate the problem. Empirical work in this area includes that by Quilerou and Fraser (2010) for the UK, and studies by

Claassen et al. (2008), Connor et al. (2008), Waetzold and Drechsler (2005), and Strijker et al (2000), for US , Australia and other countries.

A key issue addressed in many of these studies is that voluntary self-selection by the farmer participants adversely affects scheme efficiency and cost-effectiveness, because those most likely to join the scheme contribute least to the scheme objectives, referred to as 'adverse selection'. This is regarded as a particular problem where payment levels are related to average participation costs for a given group of participants since the probability of participating for profit maximising producers is negatively correlated with the opportunity costs of participation and thus with agricultural productivity. This is a key result in the Quillerou and Fraser study of the UK Higher Level Stewardship scheme and they go on to show that the impact of this is reduced to some extent by certain features of scheme implementation.

It has also been suggested that farmers with lower productivity land generate a higher level of ecological services. This is because the land is farmed less intensively and there is less damage to ecological resources. Numerous studies confirm this in a European context, including Kleijn et al. (2009), Tscharantke et al. (2005), Reidsma et al. (2006) and Stoate et al. (2001). The Kleijn et al. paper also points out that conservation benefits are disproportionately less costly to achieve on low-intensity farms. Taken together these relationships imply that participation will be biased towards farmers with lower participation costs and thus towards farmers that generate higher levels of ecological services. This would support the idea that these schemes would tend to be characterised not by 'adverse selection' but by an opposite phenomenon that might be described as 'beneficial selection'. However, while this will reduce the costs of dealing with asymmetric information, it will not totally eliminate these costs, as noted below.

This paper will investigate participation by farmers in the UK Environmental Stewardship Scheme (ESS) and how decisions to join the scheme are related to farming intensity levels on the one hand and conservation benefits on the other. In particular the paper will explore the extent to which the self selection of farmers onto the scheme influences likely scheme performance. A two-part analysis is envisaged here. The first part of the paper analyses a theoretical model for the provision of ecological services with farmers under contract to a government agency. The results of this analysis are used to motivate the empirical investigation of a sample of participants in the UK's Environmental Stewardship Schemes.

We use a unique panel dataset on different ESS agreements for different years and for the whole of the UK including characteristics on conservation options chosen and payments received.

We link this data to environmental and spatial characteristics of the land under agreement as well as production and socioeconomic characteristics of the participating farms via GIS mapping tools and different matching techniques. The empirical analysis is based on different regression models addressing problems of selection bias and endogeneity with respect to the different spatial and agreement related characteristics. A dynamic panel estimator is applied to account for lagged behavioural responses with respect to the farmers' participation and the individual contract decision (i.e. timing and individual options chosen). The results will deliver valuable empirical evidence on the nature and degree of the above outlined theoretical relationships and will crucially inform policy makers on a more adequate design of conservation schemes.

In section 2 we analyses a simple model self-selection under asymmetric information focusing in particular on the different assumptions and implications between adverse and beneficial selection. In section 3 we describe an empirical model and analysis used to test a number of the key underlying assumptions for this model. Section 4 presents a summary and some tentative conclusions of our preliminary analyses.

2. A model of Self-selection under Asymmetric information

The impairment of market efficiency when information is imperfect and asymmetric was first noted by economists in the analysis of markets for insurance (e.g. Anderson, 1956). Setting premium payments at a level that covered expected payouts inevitably meant that only those who presented a higher level of risk than average choose to take up the policies ensuring losses for the insurance company. Those with lower risk always declined to take on the insurance policy leading to complete collapse of the market even when there were willing buyers and sellers who could both gain from participating in the market. This problem was labelled 'adverse selection' in the early papers including those by Arrow (1963) and Akerlof (1970), borrowing a term previously in widespread use in the insurance industry and actuarial science (Arrow, 2009). It was also demonstrated that this problem was a feature of many other markets besides that for insurance.

The benchmark scenario involves a market for a good or service where one of the parties (e.g. the buyer of used cars in Akerlof's example) has less information about the quality and/or value of what they are buying than the seller. More specifically, the buyer knows that quality varies between sellers and has information about the average quality of the goods on the market. The buyer also knows that the seller has full information about the quality of the particular item that they are offering for sale. The problem with this market as in the insurance example above is that for any offer price made by the buyer, only items valued at or below this price will be offered for sale, so the buyer will most likely lose out in the transaction. This is because the buyer has no way of determining the quality of the item before purchase and so is likely to purchase an item that is worth less than the price being offered. This is a view of the adverse selection problem where the incentives are structured so that there is over-representation of low quality goods on the market. As in the case of insurance we can construct an example where the uninformed party (the buyer in this case) will want to progressively change the offer price to the point where the market disappears so that no items are being traded. This will be the case even when there are some potential trades between willing buyers and sellers because asymmetric information and adverse selection mean that potential trading partners cannot identify each other. As a result some potential gains from trade remain unexploited and market efficiency is reduced.

A simple model of this type of situation (adapted from Kreps,1990) can be applied in the context of Payment for Ecosystem Services (PES) schemes where an agency sets out to conclude contracts with individual farmers for the provision of ecosystem services. The agency offers a payment per hectare of land committed to the scheme on condition that the farmer undertakes specified activities on this land to enhance the agro-ecosystem and deliver higher levels of non-marketable ecosystem services. These activities will involve modification to ongoing farming practices resulting in increased costs and reduced profits from the farming operation.

In these circumstances we may assume that the ecological quality and thus the capability for generating ecosystem services on land committed to the scheme is private information to the farmer. The agency knows only average ecological quality across a group of farmers. We assume that land falls into distinct quality categories $e^1 \ldots e^N$, giving average quality $\boldsymbol{\bar{e}} = \frac{\sum_n \boldsymbol{h^n e^n(p)}}{\sum_n \boldsymbol{h^n(p)}}$, where h^n is hectares committed to the scheme of land of quality n and p is the agency's payment per hectare. We assume an upward sloping farmer participation function $\boldsymbol{h^n} = \boldsymbol{h^n(p)}$; $\frac{\partial \boldsymbol{h^n}}{\partial \boldsymbol{p}} > 0$ and an agency contract demand function that depends on payment and average quality, $\boldsymbol{D} = \boldsymbol{D}(\boldsymbol{p}, \boldsymbol{\bar{e}})$; $\frac{\partial \boldsymbol{D}}{\partial \boldsymbol{p}} < 0$, $\frac{\partial \boldsymbol{D}}{\partial \bar{e}} > 0$. The slope of this function is given by $\frac{\boldsymbol{dD}}{\boldsymbol{dp}} = \frac{\partial \boldsymbol{D}}{\partial \boldsymbol{p}} + \frac{\partial \boldsymbol{D}}{\partial \bar{e}} \frac{\boldsymbol{d}\,\bar{e}}{\boldsymbol{dp}}$ and will depend on the sign of $\frac{d\,\bar{e}}{dp}$. Since we have assumed that the first term on the right of this expression is negative while the second is positive, this means that if the third term is positive (average ecological quality increases with contract payment) then the slope of the contract demand curve could be positive (i.e. backward bending) for some payment levels.

As illustrated in Figure 1, there are three possible outcomes here for a given contract demand curve and different positively sloped participation curves. These outcomes range from a single unique equilibrium labelled 'a', through multiple equilibria labelled 'b_1' and 'b_2', to the absence of any trading equilibrium with participation curve 'C'. Only this latter outcome represents the case of 'adverse selection' described in the used car market (Akerlof, 1970), and in markets for insurance (Arrow, 1963 and many others).

This means that there is a need to distinguish between two separate impacts of asymmetric information on market efficiency. The direct impact has been addressed in this model, arising from the relationship between quality of supply and market price and focusing on the potential failure to match potential buyers with willing sellers and the consequential loss of potential gains from trade. This deadweight loss will impact on both farmers and the contracting agency. However there is a second indirect impact on market efficiency arising from the need for the uninformed party (in the examples quoted above, seller of insurance policies, buyer of used cars, or contracting agency for ecosystem services) to pay information rents in order to achieve the best possible market equilibrium. This involves a trade-off between rent and efficiency and will likely result in additional deadweight efficiency losses.

However because of the special characteristics of PES schemes we can show that $\frac{d\,\bar{e}}{dp}$ must be negative (average ecological quality declines as contract payment increases), in contrast to the examples of used cars or insurance policies. As discussed in Appendix A, the key assumption here is a negative relationship at agreement level between ecological quality and scheme payments ($\frac{\partial e^n}{\partial p} < 0$). This means that the contract demand curve for hectares committed to PES schemes must be downward sloping, so that self selection of famers onto this scheme cannot result in adverse selection and could represent an opposite phenomenon that can be referred to as 'beneficial selection'. In this situation PES contracts will not be subject to the type of direct efficiency losses discussed in the previous paragraph. On the other hand, indirect efficiency losses may be reduced but probably not to zero. The empirical analysis in the next section of this paper is focused only on the direct efficiency losses. The potential impact of beneficial selection on the indirect losses arising through the rent-efficiency trade-off is the subject of ongoing investigation by the authors.

3. Data, Empirical Model and Results

We use a comprehensive dataset consisting of different cross-sections over 5 years (2005 to 2009). It consists of individual ESS agreements for the whole of the UK including characteristics on conservation options chosen and payments received. We link this data to environmental and spatial characteristics of the land under agreement as well as production and socioeconomic characteristics of the participating farms using GIS mapping tools and matching techniques. The empirical analysis at this stage is based on simple cross-sectional regression models estimated by a standard OLS technique. As our sample consists of the full population of agreements in these years selectivity bias is not relevant here. The results will deliver valuable empirical evidence on the nature and degree of the above outlined theoretical relationships and will crucially inform policy makers on a more adequate design of conservation schemes.

Rather than estimate a complete demand system for ecological services the empirical analysis in this paper is based around the notion that the key relationships define a reduced form that can be represented by an implicit function $\boldsymbol{F}\{\boldsymbol{e}, \boldsymbol{p}, \boldsymbol{h} \ldots\ldots\} = \mathbf{0},$ where e is ecological quality, p is scheme payment and h is land committed to the scheme. The parameters of this relationship can be estimated by setting any convenient variable as dependent variable in the regression and subsequently estimating the relevant marginal impacts based on the Implicit Function Rule (see Chiang, 1984). By this mathematical specification of the functional form of the estimation model we account for likely endogeneity with respect to some of the variables used. The empirical proxies for these variables and their average values across the sample data are given in Table 1. The results of the regressions are presented in Table 2 while the estimated marginal impacts are presented in Table 3.

These latter estimates confirm that for the agreements considered in this study, ecological quality of land committed to the scheme is negatively related to scheme payments i.e. $\frac{\partial e^n}{\partial p} < 0$. As argued in Section 2 above (and in Appendix A) this means that $\frac{d\,\bar{e}}{dp} < 0$, and the agency's contract demand curve must be downward sloping at all levels of payment. The results also confirm that scheme payments increase as farming intensity increases. Thus we can conclude that self selection by farmers on to the UK ESS schemes will not undermine the possibility of market equilibrium which would lead to a direct loss of potential gains from trade that this type of adverse selection would entail.

4. Summary and Conclusions

This study explores the possibility that adverse selection (as originally understood in the analysis of insurance markets and in early papers on the economics of asymmetric information) will not arise as a result of farmers' decision to participate in UK ESS schemes. A simple model that recognises the inherent asymmetry of information in these decisions, considers a situation where an agency sets out to conclude contracts with individual farmers for the provision of ecosystem services. In these circumstances we assume that the ecological quality and thus the capability for generating ecosystem services on land committed to the scheme is private information to the farmer. The agency knows only average ecological quality across a group of farmers. Algebraic and graphical analysis reveals the possibility of two separate impacts that could result in loss of efficiency.

A direct impact could result in a complete breakdown in the system of contracts for ecosystem services where asymmetric information means that neither the agency nor the farmer can identify feasible transactions. No equilibrium is achievable and there is a deadweight loss of potential gains from trade; this is the classic example of adverse selection and is specifically considered in this study. We show that, because of the special characteristics of PES schemes, this impact will not arise in Environmental Stewardship Schemes in the UK. However, even where a set of equilibrium contracts can be concluded (as is typically the case in PES schemes) there is still an indirect loss of efficiency due to asymmetric information, as the agency pays information rents to some farmers in order to improve the allocative efficiency of the overall set of contracts. This rent-efficiency trade-off is being considered by the authors in a separate study.

Data for the empirical analysis refers to individual agreements concluded by farmers participating in the UK's Environmental Stewardship Schemes and includes information on characteristics of the farmer and of the farming operation for over 10,000 scheme participants.

Results from the regression analysis confirm that classic adverse selection is not possible ruling out a direct loss of efficiency. While this has clear advantages from a policy perspective it does not guarantee efficient contracting in PES schemes. However it raises interesting issues about potential interactions between the direct and indirect impacts outlined in the previous paragraph. In particular it raises questions about whether the presence of beneficial selection the fact that it guarantees an equilibrium set of contracts will affect the rent-efficiency trade-off, for example by reducing the amount of information rents demanded and/or by reducing the efficiency impacts of taking steps to reduce these rents. This may point to ways in which policy makers can improve the design of PES contracts.

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Appendix A: Scheme payments and average ecological quality

In the model discussed in Section 2 above, the nature of the demand function for land committed to a PES scheme depends crucially on the relationship between the average ecological quality ($\bar{e}$) of this land and the level of scheme payments (p).

Given $\bar{e} = \frac{\sum_n h^n e^n(p)}{\sum_n h^n(p)}$ we determine that $\frac{d\,\bar{e}}{dp} = \frac{\left[\sum_n \frac{\partial e^n}{\partial p} h^n + \sum_n e^n \frac{\partial h^n}{\partial p}\right] \sum_n h^n - \sum_n e^n h^n \sum_n \frac{\partial h^n}{\partial p}}{[\sum_n h^n]^2}$.

This simplifies to $\frac{d\,\bar{e}}{dp} = \frac{\left[\sum_n \frac{\partial e^n}{\partial p}(h^n)^2 + \sum_n e^n h^n \sum_n \frac{\partial h^n}{\partial p}\right] - \sum_n e^n h^n \sum_n \frac{\partial h^n}{\partial p}}{[\sum_n h^n]^2} = \frac{\left[\sum_n \frac{\partial e^n}{\partial p}(h^n)^2\right]}{[\sum_n h^n]^2}$. The sign of this expression depends on the sign of $\frac{\partial e^n}{\partial p}$ since all other terms are positive. This term represents the relationship between the ecological quality of an individual parcel of land and the level of scheme payments available for this land. We argue here that this term must be negative because of the special characteristics of PES schemes in the UK.

When payments to farmers are designed to cover the opportunity cost to farmers of participating in the scheme it is likely that payment levels will increase for farmers on land that is farmed more intensively. It has also been shown (Kleijn et al., 2009) that ecological quality declines as land use intensity increases. Taken together these imply a negative relationship between ecological quality and scheme payments for an individual parcel of land. Given the analysis above this implies a negative relationship between average ecological quality and scheme payments.

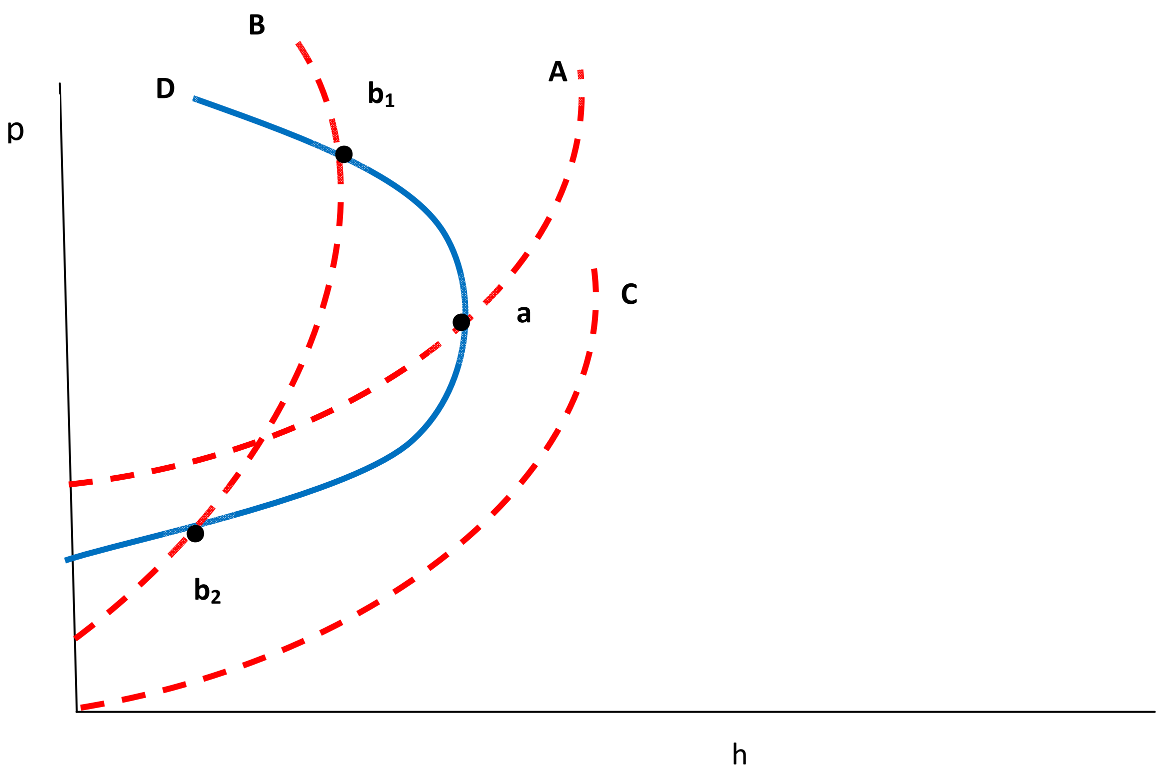

Figure 1. Self selection and market efficiency under asymmetric information

Note: D illustrates a backward bending contract demand curve (i.e. positively sloped at some price levels). Three positively sloped farmer participation curves, representing alternative sets of circumstances, are illustrated by A, B and C. With A there is a single unique equilibrium at a; there are two equilibria with B but only b_1 is stable. No market equilibrium is possible in the case of C.

Table 1. Description of the Sample Data

Variable	Empirical Proxy: Description	Sample Statistics (n = 10,951)			
		Mean	Standard Deviation	Minimum	Maximum
h	Agreement Hectares [ha under agreement]	143.49	229.21	0.34	7027.16
P	Scheme Payments [GBP per agreement]	39188.5	99959.3	54.0	2.72e+06
i	Intensity of Production [Variable Cost per ha at JCA Level]	1361.83	2901.85	190.42	193402.0
e	Inverse of Intensity [Variable Cost per ha at JCA Level $^{-1}$]	1.87e-03	1.19e-03	1.89e-05	1.41e-02
Year	Year of Agreement Start	2006.12	1.10	2005	2009
GOR1	Government Office Region 1	0.114	0.318	0	1
GOR2	Government Office Region 2	0.105	0.306	0	1
GOR3	Government Office Region 3	0.002	0.045	0	1
GOR4	Government Office Region 4	0.026	0.158	0	1
GOR5	Government Office Region 5	0.181	0.385	0	1
GOR6	Government Office Region 6	0.076	0.265	0	1
GOR7	Government Office Region 7	0.189	0.392	0	1
GOR8	Government Office Region 8	0.191	0.393	0	1
Age	Age of Average Farmer in JCA [Years]	52.985	3.379	39.5	68.5
Size	Size of Average Farm in JCA [FBS Size Code]	3.957	0.459	1.5	6
Edu	Level of Education of Average Farmer in JCA [0-School Only, 1-GSCE, 2-A Level, 3-Diploma, 4-Degree, 5-PG, 6-Apprenticeship, 9-Other]	2.145	0.669	0	4.5
Gender	Gender of Average Farmer in JCA [1-Male, 2-Female]	1.034	0.054	1	1.333
Off-farm	Off-Farm Income of Average Farmer in JCA [GBP per Farm and Year]	8819.93	4112.77	0	49875.0
Tcereal	Mainly Cereal Producing Farm (FBS Robust Type 1)	0.018	0.156	0	1
Tcrop	Mainly Crops Producing Farm (FBS Robust Type 2)	0.096	0.294	0	1
Thorti	Mainly Horticulture Farm (FBS Robust Type 3)	0.156	0.363	0	1
Tpig	Mainly Pigs Producing Farm (FBS Robust Type 4)	0.209	0.406	0	1
Tpoult	Mainly Poultry Producing Farm (FBS Robust Type 5)	0.241	0.428	0	1
Tdairy	Mainly Dairy Producing Farm (FBS Robust Type 6)	0.226	0.418	0	1
Tlfagr	Mainly LFA Grazing Farm (FBS Robust Type 7)	0.054	0.226	0	1
Tlowgr	Mainly Lowland Grazing Farm (FBS Robust Type 8)	0.002	0.048	0	1

Table 2. Results of the Regressions Analysis

Variable	*Coefficient*	*SE*	*Variable*	*Coefficient*	*SE*
B	0.023***	3.04e-04	b^2	1.594e-07***	3.98e-09
P	0.001***	2.22e-05	p^2	1.01e-08***	1.51e-11
i	-0.001	2.17e-03	i^2	1.89e-08	4.48e-08
Bp	-3.84e-08***	6.04e-10	bi	1.95e-06***	2.64e-07
Pi	-4.39e-07***	1.81e-08	year	-0.034**	0.016
gor1	-8.428***	3.165	gor2	2.378	3.810
gor3	-11.337	19.169	gor4	8.462*	5.601
gor5	1.607	2.733	gor6	-17.154***	3.781
gor7	-22.991***	2.585	age	0.199	0.283
Size	5.482***	2.067	edu	-3.929***	1.539
Gender	30.092*	16.878	offfarm	-2.713-05	2.28e-04
Tcereal	19.055	15.209	tcrop	22.612	19.001
Thorti	18.988	18.989	tpig	20.102	19.046
Tpoult	15.837	19.072	tdairy	27.923	19.075
Tlfagr	17.981	19.336	tlowgr	-8.057	26.109
Model Diagnostics					
N	10,951		$AdjR^2$	0.849	
F-test	2122.70*** [29,10,921]		LR-test (b=0)	75052.83***	
AIC	8.982		DW statistic / Rho	2.016 / -0.008	

Table 3. Estimated Marginal Effects

Variable	*Coefficient*	*SE*
$\frac{\partial e}{\partial p} = \frac{\partial i^{-1}}{\partial p}$	-4.113e-07***	1.379e-07
$\frac{\partial p}{\partial i}$	15.407***	5.079