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by

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Abstract

The link between local institutional and market failures, rural poverty and environmental degradation suggests a 'win-win' policy intervention: solve local 'constraints' and achieve both poverty alleviation and environmental goals. However, designing such interventions is problematic since exposure to constraints is unobservable and responses can be heterogeneous. In this context we evaluate the ability of the world's largest land set-aside programme, the Sloping Lands Conversion Programme (SLCP) in China, to relax local constraints on off-farm labour markets and achieve these dual objectives. A farm household model in the presence of constraints is developed. This identifies constrained and unconstrained households and predicts that the impact of the SLCP on off-farm labour supply will be larger for the former if constraints are relaxed. To test this, a novel empirical approach is employed which combines a switching regression with 'difference in differences'. Applied to panel data, these features allow unobserved sample separation, into constrained and unconstrained households, and consistent estimation of the SLCP's heterogeneous impact. Also identified is the impact on the probability of being constrained and the relative importance of constraints such as tenure security. We find some mixed support for the 'win-win' hypothesis in the case of the SLCP.

Key words: Off-farm labour supply, institutional and market failures, local separability, Sloping Lands Conversion Programme (SLCP), difference in differences, switching regression.

JEL classification: C33, J22, O22.

1 Introduction

An expansive theoretical and empirical literature on household behaviour in developing countries points to near ubiquity of missing markets, imperfect institutions and high transactions costs faced by rural households (Jacoby 1993; Key, Sadoulet and de Janvry 2000; de Janvry and Sadoulet 2005). As a result, rural households are constrained in their choice of production patterns and occupations and are precluded from many income enhancing opportunities. This economic environment conspires to limit development and even trap households in poverty (e.g. Banerjee and Newman 1994; Taylor and Adelman 2003; Matsche and Young 2004; de Janvry, Sadoulet and Zhu 2005).

At the same time, these localized failures are widely considered to be the root cause of wider environmental externalities. For instance, failures in the off-farm labour market have been shown to underpin slash-and-burn agriculture, deforestation and other apparently inefficient land-use practices in many developing countries (Bluffstone 1995; Shively and Pagiola 2004). Likewise, externalities at the river-basin level, such as increased flooding, often arise as a direct consequence of inefficient labour and land allocations (e.g. FAO 2005; Uchida et al. 2005). Thus, developing countries are doubly immiserated since, not only do these failures leave rural households impoverished by limiting opportunities for income generation, but the coping strategies that households employ frequently impose externalities upon the wider population.

It is difficult to imagine a silver lining to this cloud, and yet a closer examination of this account suggests some grounds for optimism. Since the cause of poverty here lies in inefficient allocations due to the presence of constraints, a 'win - win' intervention

immediately presents itself: by relaxing constraints both poverty *and* externalities can be reduced. Of course, this realization is not new, and numerous interventions in developing countries have been motivated in this way (e.g. Baland and Platteau 1996, 290; Carter and Olinto 2003)[1].

Ensuring local interventions are successful is not without its difficulties. Among these, the heterogeneity of rural households' exposure to constraints presents a particularly important stumbling block (Carter and Yao 2002; Vakis et al. 2005). Consequently, the impact of local interventions will also tend to be heterogeneous. Combined with the fact that constraints exposure is frequently unobserved, ensuring that a policy intervention improves efficiency is complicated not only with respect to the design and targeting of the intervention, but also in predicting household responses and undertaking retrospective evaluations[2].

This paper focuses on the mechanisms by which policy interventions can secure a 'win-win' outcome for poverty and environment by relaxing the constraints that underpin locally inefficient land and labour allocations. For this purpose, rural China is a particularly instructive setting. Firstly, China is especially prone to diverse market and institutional failures given its historically centralized economy and currently only nascent markets in rural areas (de Brauw et al., 2002). In particular, land use and exchange rights restrictions and tenure insecurity have served to limit participation in the off-farm labour market

[1] e.g. the amelioration of local credit and labour markets, the instatement of property rights or the provision of local public goods.

[2] It is well known, for example, that the assumption of global rather than local separability can mask the impact of interventions on particular types of household (Singh, Squire and Strauss, 1985; Carter and Yao 2002).

(Carter and Yao 2002), which itself has been shown to be highly segmented and discriminatory against rural migrants (Knight and Song 2005). These failures mean that off-farm incomes and remittances are frequently unavailable to many, particularly poor, households in rural China, despite being considerably more lucrative than agriculture (Rozelle, Taylor and de Brauw 1999 Taylor, Rozelle and de Brauw 2003)[3]. Indeed, the role of off-farm opportunities in alleviating rural poverty in China is often limited precisely because the poor are less able to migrate (Du, Park and Wang 2005).

Secondly, the presence of institutional and market failures has induced environmental degradation in China via inefficient land and labour allocations, e.g. high land-labour ratios (Wang, Han and Bennett 2005) and low levels of agricultural and land saving investments (Jacoby Li and Rozelle 2001). In particular, Deininger and Jin (2002, 2003) point to failures in the market for land as the cause of inefficient agricultural practices in a number of provinces of China, while Feng, Yang and Zhang (2004) highlight limited off-farm opportunities, institutional constraints and transactions costs as the main motivation for the cultivation of marginal, highly sloped lands. In turn, these household responses have been identified as major causes of large scale environmental degradation and externalities at the level of the river-basin. For instance, it is widely thought that cultivation of previously forested sloping lands in the upper reaches of the Yangtze and Yellow Rivers has induced severe environmental degradation in recent years, culminating in serious flooding and loss of life along the Yangtze River in the summer of 1998 (Uchida, Xu

[3]Knight and Song (2005) estimate that, on average, returns to off-farm employment are still 50% higher than those of on-farm employment. Our data, which was collected in two particularly poor rural areas, show that these earning differentials can reach 250%.

and Rozelle 2005)[4].

Lastly, in response to this environmental degradation, the Chinese government has implemented a major intervention. The Sloping Lands Conversion programme (SLCP) of 1999 provides compensation to households for reforesting cultivated sloped land in the upper reaches of the major river basins. The stated aims of the SLCP are twofold (Xu et al. 2004): i) curb environmental degradation and its consequences and; ii) reduce rural poverty.

What makes the SLCP an especially interesting case study is that the compensation, which constitutes the main policy instrument, is temporary. Hence, the precise mechanism by which the SLCP is to achieve its dual objectives in the long-term is open to question. Following the argument above, the success of the SLCP rests upon its ability to address the local market and institutional failures that are at the root of inefficient choices. Beyond immediate reallocation, long-term success requires that additional dynamic mechanisms are at play which remove constraints permanently, even after compensation ceases. For example, one could imagine that the SLCP acts as a push factor, pushing participants from a 'bad' equilibrium to a 'good' equilibrium where households are no longer subject to any constraints on their optimizing behaviour (Murphy, et al., 1989)[5]. Through this lens,

[4]There are some dissenting voices in this debate however. A recent FAO study questions the extent to which deforestation in the upper reaches of river basins could have lead to the flooding in 1998. Nevertheless, they found support for many other basin level externalities (FAO 2005).

[5]For example if risk averse households were not exploiting earning differentials between on and off-farm employment due to the uncertainty in the off-farm labour market but, once pushed to do so by the SLCP restrictions on land use, do not find the return journey profitable. Also, on-the-job returns and network effects could contribute to make recultivation unprofitable once the SLCP ends.

failure to address the pivotal constraints will mean that households will be inclined to revert back to former practices when compensation ceases.

The aim of this paper is therefore to examine whether the SLCP can achieve its dual objectives via the relaxation of the constraints that bind participating households. We argue that once these constraints are relaxed households are induced to supply more labour to the off-farm labour market, thereby increasing household income. In addition to the well established link between off-farm labour opportunities and deforestation outlined above, our focus on off-farm labour decisions is motivated by two observations. Firstly, there is ample evidence that off-farm opportunities offer the greatest potential for increasing rural household income (Kung and Lee 2001; Benjamin et al., 2005). The remarkable reduction of poverty in China over the last two decades was largely achieved through increases in rural incomes, of which off-farm income has become an increasingly important component in recent years (Yao 2000; Park, Wang and Wu 2002; Bowlus and Sicular 2003; Xu et al. 2004)[6]. Secondly, previous analyses have shown that off-farm incomes represent the predominant substitute for crop incomes for participants in the SLCP (Xu et al. 2004; Groom 2005; Uchida et al 2007)[7].

Our investigation of the ability of the SLCP to relax constraints relating to the off-farm labour market contributes more broadly to the literature on policy evaluation in developing

[6]Poverty (less than $1 per day or RMB900 in PPP terms) fell from 76% to 13% during this period (Chen and Ravallion 2005). Another causal factor was the introduction of the Household Responsibility System in 1980, which dismantled communes and granted long-term leases over land (Dong 1996; Liu, Carter and Yao 1998).

[7]We remain silent on the environmental outcome of reforestation per se, an issue that has received considerable attention in its own right (FAO 2005), and assume that reforestation reduces degradation.

countries by developing a theoretical and empirical approach which accommodates the aforementioned household heterogeneity. Firstly, we develop a model of the household consumer-producer in the presence of market and institutional failures, which distinguishes household types according to the nature of the constraints they face. Several testable hypotheses emerge from the model concerning the impact of the SLCP upon these distinct households. In particular, if the SLCP relaxes certain constraints, its impact will be larger for 'off-farm constrained' than for unconstrained households. We then develop a novel empirical approach, combining a switching regression with unobserved sample separation with 'difference-in-differences'. The first feature allows identification of constrained and unconstrained households, which is assumed unobservable a priori (Carter and Yao 2002; Vakis et al. 2005). The second feature accounts for selection into the SLCP in the identification of the treatment effect[8]. Finally, using household panel data from Guizhou and Ningxia provinces we test the predictions of the theoretical model and find that the impact of the SLCP on household off-farm labour supply is only positive for certain 'constrained' households. We are also able to reveal the nature of household constraints and discuss the effectiveness of the SLCP to act upon them.

The paper proceeds as follows. Section 2 describes the SLCP while Section 3 presents the household model and the hypotheses regarding the impact of the SLCP. In Section 4 the empirical approach and data are described. The results are shown in Section 5 while Section 6 discusses the policy implications.

[8]The so-called 'program evaluation problem'. See Blundell and Costa Dias (2002) and Abadie (2005) for a discussion.

2 The Sloping Land Conversion programme (SLCP)

2.1 Objectives and implementation

The SLCP is an ambitious intervention to encourage reforestation of previously converted land by compensating farmers for changes in land use practices on sloping and other types of land. The proposed scale of the project is very large, the aim being the conversion of around 15 million hectares of cropland, approximately a third of which will be on land which has a slope of at least 25 degrees (Xu and Cao 2002; Uchida et al. 2005)[9]. The principle motivation for this intervention was to address the environmental degradation associated with the deforestation and cultivation of highly sloped lands in the upper reaches of the major river basins (Wang et al. 2005). The basin level externalities have included the severe flooding in the Yangtze river basins in 1998 and drought in the lower reaches of the Yellow River. Furthermore, in both upstream and downstream areas the loss of fertile topsoil, the siltation of streams and reduced hydraulic capacity of the watercourses have inhibited the productivity of agriculture, the availability of water resources and contributed to increased incidents of flooding. Consequently, highly sloped lands have been the main focus of the SLCP[10].

[9]Since the policy commenced in 1999, approximately 15 million farmers have become participants in 20 provinces and over 27000 villages (Uchida et al. 2005). In the first 2 years of the SLCP almost 1.2 million hectares of cultivated land was converted to forestland or pasture, while an additional 1 million hectares of barren land was afforested.

[10]The environmental costs of cultivation are not limited to watersheds but also include airsheds. The increased incidence of dust-storms in the Northern plains, and the associated loss of topsoil, has also been attributed to the extensive cultivation of former pastures or natural grasslands and, despite its name, the

The main instrument of the SLCP is the direct compensation of farmers. Compensation is received in a number of different forms, levels and durations. Firstly, compensation can consist of cash, grain or seedlings for trees provided by the local forest agencies. Depending upon particular circumstances, SLCP participants receive approximately 100 to 150 kilograms of grain per mu per year and an additional Y300 per mu per year in cash[11]. Secondly, compensation varies from region to region reflecting local conditions. In the Guizhou and Ningxia, the regions studied in this paper, the level of the annual cash compensation was Y300 and Y200 per hectare respectively, reflecting distinct opportunity costs of land in each region (Uchida et al. 2005). Finally, compensation varies in its duration depending on whether sloped land is converted to 'ecological' forest (8 years) or to 'productive' forest (5 years) [12]. The rules of the SLCP state that a minimum of 80% of the reforested area in any region must be ecological forest and in our study area the rate is almost 95%[13].

SLCP has targeted these flatter areas with the purpose of returning the land to its natural grassland state (Xu and Cao 2002).

[11] 1 hectare = 15 *mu*.

[12] With 'ecological' forest farmers have no rights to forest products. For 'productive' forests participants have rights to collect non-timber forest products (e.g. fruits, nuts mushrooms and limited quantities of timber) hence compensation lasts for a shorter period of up to 5 years (Xu and Cao 2002).

[13] Ng and Pearce (2005) note the tension between encouraging more commercial or productive forests at the expense of environmental benefits, and encouraging more ecological forests to the potential detriment of incomes and hence the long-run sustainability of the programme.

2.2 Selection into the SLCP

Participation in the SLCP is in principle voluntary from the perspective of the farmers. However, the SLCP is implemented by local governments and local SLCP implementation agencies which gauge households' suitability. Furthermore, many commentators have suggested that participation is frequently involuntary (Xu and Cao 2002; Uchida et al. 2005). In previous studies it remains unclear whether participation is voluntary or compulsory. Our interviews with village leaders show that selection of participants takes on two distinct types in the study areas: either participation is compulsory or households can volunteer for selection, that is, the implementing agency chooses participants from a self selected pool. In our sample, implementation was split 60:40 between these two types. Given this, regardless of which agent eventually selects participants in the SLCP, selection into the programme is unlikely to be random. This gives rise to some empirical issues which are discussed in Section 4.

3 Theoretical model of household responses to the SLCP

In the introduction we have argued that the mechanism by which the SLCP can achieve its stated goals is by relaxing binding constraints which induce households towards inefficient allocation choices which induce the cultivation of marginal, highly sloped lands.
In order to describe this mechanism we present a farm household consumer-producer model in the presence of institutional constraints and market failure. The model shows how

heterogeneous groups of households can be distinguished, according to the severity of the constraints they face. This allows us to develop hypotheses with regard to the impact of the SLCP upon these distinct types of households.

3.1 Basic Model

Let us consider a farm household whose preferences are defined over income, y, leisure time l^l, and a vector of consumption shifters z^c. The household is endowed with a total amount of time T which is allocated between leisure l^l, on farm work l^i and off-farm work l^o, which is remunerated at a wage w^o.

The farm household is endowed with land, which is assumed to be distributed in parcels of an increasing productivity $\theta \in \left[\theta_0, \bar{\theta}\right]$. Agricultural output is produced with a technology: $q(l^i, \bar{\theta} - \theta)$, where $(\bar{\theta} - \theta)$ represents the amount of land under cultivation. That is, households cultivate their highest productivity lands until land of productivity θ, which is a decision variable. We make usual assumptions on the production technology: $q_1(.) > 0$, $q_2(.) > 0$, $q_{11}(.) < 0$, $q_{22}(.) < 0$[14]. Furthermore, we assume labour and land are complements: $q_{12}(.) > 0$[15].

Households can sell some of their production on agricultural markets, at a price p. However, there is evidence of large imperfections in the agricultural markets in China, mainly due to the distortions imposed by the State grain procurement system which drives an important wedge between buying and selling prices[16]. Burgess (2001) describes how

[14] Where: $q_1(.) = \frac{\partial q(l^i, \bar{\theta}-\theta)}{\partial l^i}$, $q_2(.) = \frac{\partial q(l^i, \bar{\theta}-\theta)}{\partial\left(\bar{\theta}-\theta\right)}$, $q_{11}(.) = \frac{\partial^2 q(l^i, \bar{\theta}-\theta)}{\partial l^{i2}}$, and $q_{22}(.) = \frac{\partial^2 q(l^i, \bar{\theta}-\theta)}{\partial(\bar{\theta}-\theta)^2}$

[15] $q_{12}(.) = \frac{\partial^2 q(l^i, \bar{\theta}-\theta)}{\partial l^i \partial\left(\bar{\theta}-\theta\right)}$. The reason for this assumption, as well as an empirical justification, are made in later sections of the paper.

[16] The system was removed in 1994, but reintroduced shortly after that because of the sharp rise in grain

Chinese rural households respond to these adverse market conditions by relying on own production to meet their food requirement[17]. The presence of quotas and agricultural taxes, which have to be paid in kind also impose agricultural production requirements[18]. In addition, uncultivated land faces a high risk of being confiscated and redistributed by the village authorities, a practice known as the 'use it or lose it' rule (Deininger and Jin 2002; Ping 2003)[19]. Uncultivated land is easily observable to village authorities and other households who may have interest in denouncing perpetrators so as to benefit from land redistribution. This confiscation risk induces households to display that land is useful and potentially produce more than optimal levels of output. In combination, imperfections in agricultural markets, taxes in kind and land confiscation risk imply that households must meet a minimum level of production. This translates into the following 'farm output constraint': $q(l^i, \bar{\theta} - \theta) \geq C$. In addition, the fact that land rental markets are non-existent or poorly developed (Carter and Yao 2002; Bowlus and Sicular 2003), suggests that households can only cultivate land allocated to them by local government or village leaders[20]. This translates into the following 'land constraint': $\theta \geq \theta_0$.

prices.

[17] De Janvry and Sadoulet (2005) describes how some households may opt out of the market and remain in autarchy in presence of such a wedge between buying and selling prices.

[18] Only few villages allow for cash payments (Brandt, Rozelle and Turner 2004).

[19] Indeed, although land readjustments have been either circumscribed or completely prohibited by the 1999 revised Land Management Law for a 30 year period, legal provisions have not always translated into effective tenure security.

[20] Again, this is reflected in our data in which only 12% of households rent land in or out. Only 7% of all cultivated land is involved in such transfers. Furthermore, the majority of such rental exchanges is informal and generally does not give rise to any monetary compensation (Bowlus and Sicular 2003).

With utility represented by the twice differentiable, concave function: $U(y, l^l, z^c)$, with grain production the numeraire ($p = 1$), hence $y = q(l^i, \bar{\theta} - \theta, z^q) + w^o l^o$, and $l^l = T - l^i - l^o$, the household maximization problem can be represented as follows:

$$\max_{l^i, l^o, \theta} U(q(l^i, \bar{\theta} - \theta, z^q) + w^o l^o, T - l^i - l^o, z^c) \tag{1}$$

s.t.

$$q(l^i, \bar{\theta} - \theta) \geq C \qquad (\mu^c) \tag{2}$$

$$\theta \geq \theta_0 \qquad (\mu^\theta) \tag{3}$$

$$l^i \geq 0 \tag{4}$$

$$l^o \geq 0 \tag{5}$$

where μ^c and μ^θ are the Lagrange multiplier associated with constraints (2) and (3) respectively.

We consider only households who work both on- and off-farm. Appendix A shows how households' behaviour in the off-farm labour market differs according to whether constraints are binding on their optimizing behaviour. When no constraint is binding on household behaviour, or when only the land constraint is binding, households' production and consumption choices are separable (see de Janvry and Sadoulet 2005). Such households are labeled hereafter 'off-farm unconstrained' households. They equalize the returns of on- and off-farm labour, and cultivate land until the marginal productivity of labour on that land meets the off-farm wage. Their decision wage in the off-farm labour market is the market wage.

It is easy to show that households for whom the farm output constraint is binding also face a binding land constraint, that is, they use all available land. Such households are labelled hereafter 'off-farm constrained' households. The decision price in the off-farm labour market is no longer the market wage, but a shadow wage, which depends on the farm output constraint and which is lower than the off-farm market wage. The marginal productivity of on-farm labour of such households is lower than the off-farm market wage and leads to excessive labour allocated on-farm compared to the optimal situation[21]. Surplus on-farm labour is characteristic of rural China (Knight and Song 2005).

Appendix A presents reduced form equations of the off-farm labour of these different groups of households. The important distinction between the 'off-farm constrained and 'unconstrained' group is that, due to the idiosyncratic shadow decision wage, off-farm labour supply of constrained households is impacted by the presence of the output constraint, while it only depends on production characteristics and households preferences for unconstrained households.

The determinants of off-farm labour supply differ depending upon which group a household belongs to. As will be explained in Section 4 below, this provides the basis for the empirical identification of these heterogeneous groups of households. Further, the impact of the SLCP will be heterogeneous across households, depending upon their exposure to constraints. We now focus on the impact of the policy.

[21] Brandt et al. (2004) also note that in kind quotas may compel households to oversupply agricultural labour relative to the profit maximizing level.

3.2 The Impact of the SLCP

This model allows us to illustrate that participation in the SLCP has two likely effects. Firstly, restrictions are imposed on land use, as the SLCP targets highly sloped lands of the lowest productivity, which were previously cultivated. The programme imposes $\theta = \tilde{\theta}$, with $\tilde{\theta} > \theta_0$[22]. The land constraint (3) is tightened as a result. Secondly, the programme provides subsidies, which are largely distributed in grain, in order to compensate from the lost production on converted land. Let A be the amount of unit subsidy distributed for every piece of land set aside. The total amount of subsidies is thus: $A(\tilde{\theta} - \theta_0)$. Where over compensation occurs, grain subsidies act to relax the 'output' constraint (2) for those households that are off-farm constrained.

The household's optimization problem can now be represented as follows:

$$\max_{l^i, l^o} U(q(l^i, \bar{\theta} - \tilde{\theta}, z^q) + w^o l^o + A(\tilde{\theta} - \theta_0), T - l^i - l^o, z^c) \tag{6}$$

s.t.

$$q(l^i, \bar{\theta} - \tilde{\theta}) + A(\tilde{\theta} - \theta_0) \geq C \qquad (\mu^c) \tag{7}$$

$$l^i \geq 0 \tag{8}$$

$$l^o \geq 0 \tag{9}$$

[22]It is assumed that at this stage, once the household has been chosen to participate in the program, the amount of land enrolled is not a decision variable for the household. In addition, we assume that $\tilde{\theta} > \hat{\theta}$ implying that the programme is supposed to target only land which was previously cultivated, and this is observable so that $\tilde{\theta} > \hat{\theta}$ is enforceable. This is a plausible assumption given that in our sample all land is used in cultivation.

We obtain the following proposition on the impact of the programme on household off-farm labour supply:

Proposition 1 *(a) The SLCP generates a positive substitution effect from on-farm to off-farm labour by reducing the amount of cultivated land.*
(b) The revenue effect of the SLCP subsidies on the off-farm labour supply is either negative, nil, or positive, according to whether households are over, exactly, or under compensated for their loss in agricultural production, respectively.
(c) In addition to the substitution and revenue effects, the SLCP grain subsidies relax the 'output constraint', which increases the off-farm labour supply of 'off-farm constrained' households.

Proof: See Appendix A.

The intuition for Proposition 1(a) is the following. Participation in the SLCP reduces cultivated land for SLCP participants. As labour and land are complements in the agricultural production function, participation in the SLCP induces a positive substitution effect from on-farm labour to off-farm labour[23]. Proposition 1(b) is established from the fact that, if the subsidies exactly compensate households for their loss of agricultural income, leisure does not vary, and the revenue effect is nil. Conversely, if households are

[23]Given that this assumption is pivotal to the predictions we make in the following sections, we have estimated the agricultural production function using a multi-output distance function approach (Battese and Coelli, 1992). We estimated a Trans-log production function in the two main outputs (wheat and potatoes) in land, household labour and fertilizer. The cross partial of land and labour was positive (0.12) and significant at the 5% level.

over (under) compensated, there is a positive (negative) revenue effect and leisure will increase (decrease) assuming normality. This describes the revenue effect of the SLCP which is dominated by the substitution effect if the marginal subsidy, A, is lower than the (real) marginal productivity of land under cultivation[24].

Proposition 1(c) captures the heterogeneity in household responses to the SLCP. In addition to the substitution and revenue effects, relaxing the 'output constraint' via SLCP subsidies makes the decision wage of constrained households converge towards the market wage as μ^c, the shadow price of the production constraint, decreases. The SLCP subsidies induce an upward shift in constrained households' shadow off-farm wage, which in turn generates an increase in their off-farm labour supply. When SLCP participants are completely released from their production constraint, their decision wage becomes the market wage. In sum, the impact of the SLCP on off-farm constrained households will differ from that on off-farm unconstrained households in one important dimension: the relaxation of the 'output constraint'.

[24]Indeed, the implicit function theorem yields:

$$\frac{dl^o}{d\tilde{\theta}} = \frac{[q_2(.) - A][U_{11}(.)w^o - U_{21}(.)]}{U_{11}(.)(w^o)^2 - U_{12}(.)w^o - U_{21}(.)w^o + U_{22}(.)}$$

4 Econometric Approach

Propositions 1 (a) - (c) point to a number of distinct hypotheses for those households that participate in the off-farm labour market[25]:

Hypothesis 1: The off-farm labour supply of unconstrained households depends only on production side characteristics and on the household's preferences, while that of the constrained households depends also on the presence of the 'farm output constraint'.

Hypothesis 2: If the revenue effect does not offset the substitution effect, participation in the programme should induce an increase in the off-farm labour supply of all households.

Hypothesis 3: The increase in off-farm labour supply should be larger for off-farm constrained than for off-farm unconstrained households.

Hypothesis 4: Participation in the SLCP reduces the probability of being off-farm constrained, since participation in the SLCP may fully relax the production constraint, so that households which were formerly 'off-farm constrained' households become 'off-farm unconstrained'.

In exploring these hypotheses, the empirical analysis must overcome two important challenges. Firstly, it must accommodate the heterogeneous households identified by the theoretical model: the off-farm constrained and unconstrained. This is particularly difficult since the constraints faced by rural households are not only numerous but also predominantly unobservable (Vakis et al. 2005). Secondly, in evaluating the impact of any programme using non-experimental data, the problem of selection bias must be addressed[26].

[25] Elsewhere we analyse the discrete decision to participate in the off-farm labour market (Groom et al. 2006).

[26] The program evaluation literature is replete with discussion of this particular issue. See in particular

We propose a novel solution to these two empirical issues which combines a switching regression with unobserved sample separation with difference in differences (DID). Firstly, the switching regression model accommodates heterogeneity among households by separating the sample and defining two distinct *regimes*. This approach is consistent with our theoretical model, which points to the existence of two distinct regimes in the analysis of off-farm labour supply: constrained and unconstrained. Since separation is unobserved and these regimes cannot be defined *a priori,* the identification and interpretation of the regimes is drawn from analysis of the coefficients of the regime regressions and by reference to the theoretical model. That is, constrained households can be identified by the statistical significance of constraint variables in the labour supply equation. This constitutes a test of hypothesis 1.

Secondly, the presence of panel data allows us to control for selection into the SLCP using difference in differences (DID) (Blundell and Costa-Dias, 2000; Abadie, 2005). Combining DID with the switching regression model makes it possible to identify the 'treatment effect' of the SLCP on each regime and hence test whether this effect is heterogeneous. In this way we can test Hypotheses 2 and 3. As explained in the following section, our empirical approach also yields a direct test of hypothesis 4.

4.1 Difference in Differences (DID)

We use DID to estimate the Average Treatment Effect (ATE) of participation in the SLCP on off-farm labour supply. Under suitable assumptions DID controls for endogeneity of the participation decision and consequently provides a consistent estimate of the ATE

Heckman et al. (1997) and Blundell and Costa-Dias (2000) and for comprehensive discussions.

(Heckman et al., 1997). We present this approach within a general framework which draws from Chamberlain (1982)[27].

We specify a reduced form labour supply function as a components of variance model. For each household i $(i = 1, .., N)$ labour supply at time t $(t = 1, .., T)$, l_{it}, is modelled as a linear function of $K-1$ household and village level characteristics (X_{it} and Z_{it} respectively), and unobservable components of variance: ϕ_i, λ_t and u_{it}. The latter represent permanent household specific, time specific and individual transitory effects respectively, and we make the usual assumptions about them[28]. Finally, the dependence of labour supply on participation in the SLCP is captured by the dummy variable D_{it}, and the scalar α represents the ATE of the SLCP on the outcome variable l_{it}:

$$l_{it} = \alpha D_{it} + \beta' \mathbf{x}_{it} + \phi_i + \lambda_t + u_{it} \tag{10}$$

where $\mathbf{x}_{it} = [X_{it}, Z_{it}]$ is a $(K-1)$xNT matrix and β' is a 1x$(K-1)$ vector of parameters. For simplicity of exposition, the treatment effect in this model (α) is assumed identical for all households. This assumption can easily be relaxed by including interactions with D_{it}. To account for endogeneity and obtain consistent estimates of the parameters of this model we follow Chamberlain (1982) and recast (10) in terms of the following $T-$variate

[27] Abadie (2005, p2-5) provides a succinct explanation of the DID method which effectively draws on Chamberlain (1982).

[28] These are (Hsiao, 1986): i) $E[\phi_i] = E[\lambda_t] = E[u_{it}] = 0$; ii) $E[\phi_i \phi_j] = \begin{cases} \sigma_\phi^2 & \text{if } i = j \\ 0 & \text{otherwise} \end{cases}$; iii) $E[\lambda_t \lambda_s] = \begin{cases} \sigma_\lambda^2 & \text{if } t = s \\ 0 & \text{otherwise} \end{cases}$; iv) $E[u_{it} u_{js}] = \begin{cases} \sigma_u^2 & \text{if } i = j \text{ and } t = s \\ 0 & \text{otherwise} \end{cases}$.

regression for a household i, ignoring λ_t for the moment[29]:

$$\mathbf{l}_i = (I_T \bigotimes \boldsymbol{\beta}^{*\prime})\, \mathbf{x}_i^* + \mathbf{e}\phi_i + \mathbf{u}_i \tag{11}$$

where T is considered fixed and: $\mathbf{e}'$ is a 1xT vector of ones; $\mathbf{l}_i'$ is 1xT; $\mathbf{x}_i^{*\prime}$ is a 1xKT matrix of K regressors, now including D_{it}; $\beta^{*\prime}$ is a 1xK parameter vector, now including α.

Correlation between ϕ_i and $\mathbf{x}_i^*$ can be accounted for by following linear projection[30]:

$$E\left[\phi_i|\mathbf{x}_{it}^*\right] = \mu + \Sigma_t \boldsymbol{\gamma}_t' \mathbf{x}_{it}^* = \mu + \boldsymbol{\gamma}' \mathbf{x}_i^* \tag{12}$$

Taking the expectation of (11) and inserting (12) yields:

$$E\left[\mathbf{l}_i|\mathbf{x}_i^*\right] = E\left[\mathbf{e}\phi_i + (I_T \bigotimes \boldsymbol{\beta}^{*\prime})\, \mathbf{x}_i^* + \mathbf{u}_i|\mathbf{x}_i^*\right] = \mathbf{e}\mu + \Pi \mathbf{x}_i^* \tag{13}$$

where $\Pi = I_T \bigotimes \boldsymbol{\beta}^{*\prime} + \mathbf{e}\boldsymbol{\gamma}'$ and is a TxKT matrix of parameters. This implies time varying coefficients for $\mathbf{x}_i^*$. Using (11) and (13) gives:

$$\mathbf{l}_i = \mathbf{e}\mu + (I_T \bigotimes \mathbf{x}_i^{*\prime})\, \boldsymbol{\pi} + \mathbf{v}_i \tag{14}$$

where $\mathbf{v}_i = \mathbf{l}_i - E\left[\mathbf{l}_i|\mathbf{x}_i^*, \phi_i\right]$ which is orthogonal to $\mathbf{x}_i^*$ by definition, and π' is a 1xKT^2 vector of coefficients (Hsiao 1986)[31]. Provided that the $\mathbf{x}_i^*$ are time varying, the correlation

[29] This discussion draws from Hsiao (1986, 57) and Abadie (2005, 2-5)

[30] Chamberlain (1982) was concerned with accommodating unknown error structure and formulated his model in terms of a general non-linear projection.

[31] E.g. for $K = 2$ and $T = 2$ $(t = 0, 1)$: $\Pi = \begin{bmatrix} \beta_1 + \gamma_{10} & \beta_2 + \gamma_{20} & \gamma_{11} & \gamma_{21} \\ \gamma_{10} & \gamma_{20} & \beta_1 + \gamma_{11} & \beta_2 + \gamma_{21} \end{bmatrix}$ and $\pi' = \begin{bmatrix} \pi_{111} & \pi_{211} & \pi_{121} & \pi_{221} & \pi_{112} & \pi_{212} & \pi_{122} & \pi_{222} \end{bmatrix}$ where the indices refer to the coefficent on the k^{th}

between $\mathbf{x}_i^*$ and ϕ_i can be modelled and a consistent estimate of $\boldsymbol{\pi}$ obtained. In particular, as is the case with more conventional panel approaches to DID, this approach allows for any type of selection into the SLCP operating through the fixed effect ϕ_i[32].

Adapting (10) to the case in hand is straightforward. We consider a two period model: pre- and post- programme, and define $t = 0, 1$. Allowing intercepts to vary over time and noting that $D_{i0} = 0$ for all i, then (14) translates into the following labour supply equation:

$$l_{it} = \lambda_t + \alpha D_{it} + \gamma_{D1} D_{i1} + \beta' \mathbf{x}_{it} + \gamma_0' \mathbf{x}_{i0} + \gamma_1' \mathbf{x}_{i1} + v_{it} \tag{15}$$

from which α, as well as the parameters in β and γ_t, can be consistently estimated using OLS. We use this approach to identify α, and the coefficients on interactions with D_{it} and the time varying explanatory variables we expect to be correlated with ϕ_i[33].

4.2 Switching regression using DID

As discussed above, households face idiosyncratic institutional and market failures. Consequently, it would be unusual for all households to be constrained in any given region and, if they are, for all constraints to be equally important for every household. In addition to this, the cause of constraints is not always observable (Carter and Yao 2002; Vakis et al. 2005). In this setting, and given the theoretical model of Section 3 the econometric model

regressor at time t in the t^{th} equation of (14).

[32] That is, DID allows $E[\phi_i, D_{it}] \neq 0$, hence removing this motive for estimation of the participation decision (Heckman et al. 1997).

[33] Equation (15) corresponds closely to equation (4) in Abadie (2005, 5). In his exposition, Abadie only includes in the projection those variables considered to be endogenous, and we do likewise. This constitutes a restriction on γ_t which we motivate in Section 5.

of labour supply decisions accommodates the following features: (i) a reduced form approach; (ii) the source of separability is not confined to a single market failure; (iii) recognition of heterogeneity across households with respect to the nature and extent of constraints; (iv) unknown sample separation between constrained and unconstrained households. These features of the problem point to a switching regression with unobserved sample separation as the most suitable econometric framework (Hartley 1978).

The model belongs to the family of mixture-distribution models that aim to 'unmix' the sample by simultaneously identifying the stochastic structures governing the separation of the sample into two latent regimes while explaining the behavioural decisions of each observation in the regimes (Maddala 1983; Hartley 1978). However, what distinguishes our approach from previous applications (e.g. Vakis et al., 2005) is that the regime regression equations are of the form shown in equation (15). This innovation means that not only are points (i)-(iv) above accommodated, but we can also account for endogeneity of the variables of interest by exploiting the panel nature of the data. In particular, we can consistently estimate treatment effects using DID in each equation of the switching regression.

The model uses the following system of equations to define household behaviour:

$$l_{it}^{*j} = \lambda_t^j + \alpha^j D_{it}^j + \gamma_{D1}^j D_{i1}^j + \beta^{j\prime}\mathbf{x}_{it}^j + \gamma_0^{j\prime}\mathbf{x}_{i0}^j + \gamma_1^{j\prime}\mathbf{x}_{i1}^j + v_{it}^j \tag{16}$$

$$\Lambda_{it} = \lambda_t^\Lambda + \alpha^\Lambda D_{it}^\Lambda + \gamma_{D1}^\Lambda D_{i1}^\Lambda + \beta^{\Lambda\prime}\mathbf{x}_{it}^\Lambda + \gamma_0^{\Lambda\prime}\mathbf{x}_{i0}^\Lambda + \gamma_1^{\Lambda\prime}\mathbf{x}_{i1}^\Lambda + \varepsilon_{it} \tag{17}$$

where $j = 1, 2$. l_{it}^{*j} represents the latent off-farm labour supply of two heterogenous groups

or regimes of households and Λ_{it} is a latent variable that determines sample separation. The error terms are assumed to be normal $i.i.d$ disturbances with zero means and variance σ_j^2 $(j = 1, 2)$ with $\sigma_\Lambda^2 = 1$ for identification. For each household i in each time period t we only have data on the observable counterpart of l_{it}^{*j} such that:

$$l_{it}^{*j} = \begin{cases} l_{it}^1 \text{ if } \Lambda_{it} > 0 \\ l_{it}^2 \text{ if } \Lambda_{it} \leq 0 \end{cases} \tag{18}$$

Given that we cannot observe the regime classification, each randomly selected household i will have a probability $1 - \rho = \Phi\left(-x_{it}^{\Lambda}\beta^{\Lambda}\right)$ of belonging to the first regime and probability ρ of belonging to the second[34]. The probability density function of each observation is hence given by the mixture of two distributions[35]. The resulting likelihood function is maximised with respect to the parameters using the E-M method as articulated by Hartley (1978).

To interpret the empirically defined regimes we refer to the theoretical model. Equations (30) and (36) in Appendix A show: $\mathbf{x}_{it} = \left[p, w^o, \bar{\theta}, \theta_k,\ T, z^q, z^c\right]$, where $(\theta_k \in (\theta_0, \hat{\theta}))$ for the 'off-farm unconstrained' households, and according to (44):

$\mathbf{x}_{it} = \left[p, w^o, C, T, \bar{\theta}, \theta_0, z^q, z^c\right]$ for the 'off-farm constrained' households. The difference between these groups is the presence of the constraint variables, C, in the latter. The constrained regime could then be identified if the variables associated with the production constraint are significant in one regime and not the other. This would be an indication that

[34] We use a general notation for exposition, where the superscripts define the relevant equation of the switching regression.

[35] Labelling these distributions φ_1 and φ_2, and using general notation for the explanatory variables and parameters, the distribution function will have the form: $f\left(l_{it}^j\right) = (1-\rho)\,\varphi_1\left(l_{it}^1 - x_{it}^1\beta^1\right) + \rho\varphi_2\left(l_{it}^2 - x_{it}^2\beta^2\right)$ and the likelihood function will be: $L\left(\beta^1, \beta^2, \beta^\Lambda, \sigma_{v_1}, \sigma_{v_2}\right) = \prod_{i=1}^{N} f\left(l_{it}\right)$

our sample represents observations drawn from two distinct samples and would be a test of hypothesis 1. One feature common to each equation is the average treatment effect, α^j and α^Λ. If there is support for hypothesis 1 then Hypotheses 2 and 3 can be tested by inspection of the estimates of α^1 and α^2, while hypothesis 4 can be tested by inspection of the estimate of α^Λ in the switching equation, which also yields information about what determines whether a household is in one regime or another.

In order to identify the parameters of interest in this model it is assumed that the error terms are independent across equations[36]. This assumption means that the disturbance term in (17), which affects the probability of falling into the first regime, is independent of that affecting the continuous labour supply decision[37].

4.3 Data

The data set contains information on 286 households in Ningxia (155) and Guizhou (131)[38]. In tandem with the household surveys 40 village questionnaires were undertaken in order to obtain village level data. Data for the pre- and post-programme periods were

[36]Since we do not observe $l = l_1$ and $l = l_2$ simultaneously the following variance covariance structure applies (Hartley 1978): $\mathbf{\Omega} = \begin{bmatrix} \sigma^2_{v_1} & . & 0 \\ . & \sigma^2_{v_2} & 0 \\ 0 & 0 & \sigma^2_{\varepsilon} \end{bmatrix}$

[37]This assumption is an integral part of the switching regression model with unobserved sample separation of Hartley (1978). The assumption is routinely employed in the applied labour economics literature (e,g, Vakis et al., 2005; Roig, 1999; Dickens and Lang, 1985).

[38]The SLCP survey was administered by moderators from Beijing University. The survey was part of broader research project that was completed in October 2006.

collected where the pre-programme data was retrospective and referred to 1999 for both participants and non-participants. Table B1 in Appendix B presents descriptive statistics of the variables included in the switching regression. We follow previous work in this area (e.g. Vakis et al. 2005) and estimate the model on a sub-sample of the data including only those households that supply off-farm labour both pre- and post-programme[39]. This reduces the number of households to 159, 30% of which are non-participants in the SLCP.

4.4 Explanatory Variables

Section 3.1. discussed the likely sources of constraints on household behaviour. Two main factors of constraints have been identified in the literature: the incompleteness of local labour and agricultural markets, and institutional constraints (Burgess 2001; Carter and Yao 2002; Bowlus and Sicular 2003). Our theoretical model suggests that household size and composition will influence off-farm labour supply, not only through the labour endowment effect, but also through its influence on the quantity of labour that needs to be allocated to cultivation in order to meet quotas and family food requirements in the context of imperfect agricultural markets (Burgess 2001). The presence of young children and pensioners, who do not contribute to the labour endowment but represent extra mouths to feed, are included in the analysis to capture the latter effects. As an indicator of transaction costs we use distance to a main road to capture the ease of access to agricultural and labour markets. Institutional constraints are captured by the development of land rentals within the village (Deininger and Minten 1999) and by the distance from

[39] Consequently, we do not deal with censored data. Groom et al. (2006) analyse the discrete decision and find that the SLCP induces increased participation in the off-farm labour market.

the village to the nearest credit agency (Key et al. 2000), while the level of tenure security is proxied by soil quality at the village level. Soil quality is found to be highly correlated with tenure security in the literature. Frequently this is because the disincentive effect of land reallocations on farmers' investment incentives results in land degradation (Jacoby et al. 2001; Brandt, Rozelle and Turner 2004). Unfortunately, the approach described in Section 4.1 fails to deal with the endogeneity problem inherent in household level institutional constraints, since these data are time invariant [40]. Consequently, we follow Carter and Yao (2002) and Deininger and Minten (1999) and include village level variables to proxy for such institutional constraints and mitigate the endogeneity problem that arises from using household level variables.

Although the estimation of off-farm labour supply requires reasonably complete and accurate data on wages, we were unable to obtain such reliable information, for three main reasons. Firstly, we observe a very low variability of off-farm wages between the two periods of observations, which may indicate that people are mis-reporting wages. Secondly, employment in Township and Villages Enterprises (TVEs) provides significant in kind payments, so that the comparison of self-employed earnings with TVEs' wages may hide significant differences. Thirdly, our analysis is complicated by a large number of households who do not provide any information on wages. Since the type of off-farm labour opportunities in the region is likely to drive the main differences in off-farm earnings, using a regional dummy mitigates difficulties arising from a complex wage structure. Education

[40] Household level perceptions of tenure security, rental rights or access to credit can be endogenous to the off-farm labour supply decision.

is used as a household level proxy for off-farm wages[41]. In addition, the panel structure of our data allows to control for household specific differences in labour quality that may influence off-farm earnings and are constant over time.

4.5 Treatment Variables

We include three treatment variables: participant in the SLCP D_{it} (*treat*), labour supplied outside of the village as opposed to within (*trout*), which is an interaction between the indicator *outdum* (a dummy variable equal to one if labour is supplied outside the village) and *treat*, and a regional interaction effect (*treatreg*), because the programme's compensation differs across regions. The coefficients on each of these variables represent the treatment effects. As discussed above, selection into SLCP is likely to be non-random. In addition to this, the decision to work outside of the village and any interaction with this is also likely to be endogenous. Identification of the parameters associated with these variables is obtained using the approach described in Section 4.1. That is, each endogenous variable is included in the projection in equation (12). In terms of equation (15) for the participation dummy, D_{it} (or *treat*), identification requires the inclusion of D_{i1} (*participation*) and a time varying intercept, λ_t (*year*)[42]. For *outdum* and *trout* identification requires the inclusion of *outPRE* and *outPOST,* which are the values of *outdum* in periods 0 and 1 respectively. In terms of (15) these are components of $\mathbf{x}_{it}, \mathbf{x}_{i0}$ and $\mathbf{x}_{i1}$ respectively. Just as the DID approach allows any type of selection into the

[41] For the same reasons, a similar approach is employed and found to be robust in other studies of the rural labour market in China (Zhang, Rozelle and Huang 2001; Lohmar, Rozelle and Zhao 2000).

[42] To reiterate, D_{i0} drops out since it is always zero.

programme based on the household fixed effect, ϕ_i, endogeneity through the fixed effect of *outdum* and *trout* is also accounted for using this approach.

5 Results

In this section we present the results of our adapted switching regression model which analyses the off-farm labour supply decision. The characteristics of the identified constrained and unconstrained households are then discussed.

5.1 Household heterogeneity

Table 1 shows the results of the switching regression for the separate regimes of the off-farm labour market (columns 3 and 4), as well as the initial pooled regression for comparison purposes (column 2)[43]. The switching regression separates the sample into two distinct regimes. Sample separation is unobserved and hence the interpretation of the regimes can only be made by reference to the results of the component regressions in Table 1 and the 'switching' equation shown in Table 2. Table 1 shows that the two regimes have an interpretation that is consistent with our theoretical model.

In Regime 1 the variables that were included to reflect market failures and institutional constraints, the so-called 'constraint' variables, are found to be highly significant. The model predicted that only the off-farm labour supply of constrained households is influenced by these variables. For such constrained households, the presence of children

[43]In both tables, * indicates significance at 10%, ** significance at 5%, and *** significance at 1%. Standard errors are robust.

under 16 years of age (*child*) and elderly household members (*elderly*) reduce off-farm labour supply, as expected. The remoteness from credit agencies (*credit access*) significantly reduces off-farm labour supply. The development of the land rental market (*rentease*) significantly increases off-farm labour supply, by over 127 days per year in our sample. Ease of land rental is, indeed, the most economically important constraint in the determination of off-farm labour supply, followed by the presence of pensioners. These findings are coherent with previous evidence of a strong impact of land transfers possibilities and tenure security on the development of off-farm labour in rural China, as well as the influence of credit constraints on production decisions of Chinese rural households (Feder et al. 1990)[44].

Conversely, in Regime 2 the only significant variables are those which reflect the structure of the local labour market and the household factor endowments. Indeed, only the regional dummy (*regdum*), the dummy indicating the destination of off-farm labour (*outdum*), land and household size are significant. Importantly the constraint variables are insignificant. The theoretical model showed that this is a feature of off-farm unconstrained households. We thus reject the null hypothesis of homogeneous household behaviour in favour of hypothesis 1 and conclude that households are heterogeneously exposed to the presence of market failure and institutional constraints. The separation into regimes is also seen to be robust when we compare the outcome under the two regimes to the pooled regression in column 2 of Table 1. Many of the explanatory variables in the pooled regression are insignificant and yet the unobserved sample separation shows that ignoring household heterogeneity in our sample masks important behavioural differences.

[44]See Li et al. (1998); Carter and Yao (2002); Deininger and Jin (2003) and Bowlus and Sicular (2003).

Dep var: Off-farm lab supply	Pooled		Regime 1: Constrained		Regime 2: Unconstrained	
RHS variables	Coeff	(s.e)	Coeff	(s.e)	Coeff	(s.e)
	'Projection' Variables (see Eq 15)					
Year (λ_t)	58.0	(59.9)	27.4	(26.1)	90.7	(106.4)
Participation (D_{i1})	-41.6	(50.1)	-82.3***	(22.8)	-133.6*	(83.9)
OutPRE (x_{i0})	-160.1	(75.5)	125.2***	(16.9)	-292.2***	(114.8)
OutPOST (x_{i1})	16.1	(80.6)	-115.5**	(39.7)	69.6	(75.3)
	Treatment Variables					
Treat	-21.1	(94.3)	194.1***	(52.5)	-96.8	(127.2)
TreatReg	3.7	(65.6)	-175.1***	(44.6)	25.3	(83.2)
TreatOut	36.7	(71.2)	-189.3***	(45.1)	80.6	(82.5)
	Other Variables					
Outdum	203.1	(105.7)	38.1	(33.4)	295.4***	(132.5)
Region	90.4***	(44.5)	26.7	(29.1)	117.3**	(62.2)
Land	-0.5	(1.2)	0.5	(0.4)	14.3***	(2.9)
Education	183.0***	(45.4)	96.0***	(21.5)	63.5	(55.6)
HH size	-35.4	(36.6)	-6.1	(18.8)	-49.8	(37.7)
(HH size)^2	8.1***	(2.8)	2.6**	(1.4)	6.8***	(2.5)
	Constraint Variables					
Elderly	37.1	(48.6)	-80.3***	(17.5)	21.9	(77.7)
Child	-42.7*	(30.8)	-57.5***	(15.4)	-38.5	(43.4)
Rentease	-2.5	(43.0)	-127.7***	(18.3)	-0.01	(75.1)
Credit Access	0.4	(3.5)	-4.7***	(1.7)	4.3	(4.7)
Soil Quality	50.2	(33.0)	56.8***	(17.4)	-74.1	(48.1)
Constant	8.6	(178.0)	338.4***	(84.7)	162.9	(269.3)
R^2	25%		65%		31%	
F-Stat (p value)	5.25 (0.00)		16.41(0.00)		12.80 (0.00)	
Observations	322		145		177	
Sample Proportion	1		0.37		0.63	

Table 1: Switching Regression: Regime Regressions

Descriptive statistics for each of the two groups in Table B2 in Appendix B confirm that sample separation is consistent with our hypotheses. Households that are subject to constraints supply labour off-farm at a shadow wage, which is lower than the market wage. Their off-farm labour supply should consequently be lower than that of unconstrained households. Indeed, the average off-farm labour supply of households belonging to the constrained group is 302 days per year, well below the average of 433 days per year for unconstrained households[45].

5.2 The treatment effect of the SLCP

Estimates of the ATE of the SLCP are contained in Tables 1 and 2[46]. In Table 1, all three treatment effects (coefficients on *treat*, *treatreg* and *trout*) are significant at the 1% level in the constrained regime, while none is significant in the unconstrained regime. For the constrained households, the impact of the SLCP is large, positive and significant at the 1% level inducing an extra 194 days per household per annum on average. This represents an increase of 56% with respect to pre-programme off-farm labour supply of SLCP participants. For the unconstrained regime, the treatment effect is negative but not statistically significant. However, for constrained households, programme participation has a negative, significant and large impact on the off-farm labour supply of those who supply their labour outside of the village. This negative impact offsets the treatment effect of the programme, so that the overall effect of the programme on such households is not statistically different from zero. The regional treatment effect (*treatreg*) is also significant

[45] A t-test shows that this difference is statistically significant.

[46] Strictly speaking this is the average treatment on the treated (Heckman et al., 1997).

and negative, indicating that the treatment effect on households in the region of Guizhou is negative. The scope of the coefficient implies that the treatment effect of the programme on households in Guizhou is not statistically different from zero. For those households in Guizhou that supply their labour outside the village the treatment effect is negative, but not statistically different from zero even at a 10% level.

To conclude, we reject the null hypothesis in favour of hypothesis 2: the substitution effect of programme participation offsets the revenue effect and the overall effect of the SLCP is to induce participating households to reallocate their labour towards off-farm employment. We are also able to reject the null in favour of hypothesis 3: the impact of the programme on off-farm labour supply is larger for constrained than for unconstrained households. This implies that part of the effect of programme participation operates through the constraints that impede household behaviour, as is further discussed in the next subsection. However, the labour reallocation which results from programme participation is realized at the village level, the programme having a negative impact on labour which is supplied outside the village, despite off-farm activities being more lucrative outside the village than within[47]. We can thus conclude that the SLCP does appear to relax local constraints that were forcing households to supply excess labour on land, but does not address, and may even sharpen, the constraints on the off-farm labour market itself, namely those which restrict migration outside of the locality[48]. We now turn to the nature of local constraints,

[47] Our, albeit imperfect, data on wages indicates that average earnings outside the village are 50% higher than within the village.

[48] Anecdotal evidence suggests that one reason for this may be that the presence of the household is required by program participation, for example because participating households have to monitor reforested areas.

and the impact of the programme upon them.

5.3 The nature of the constraints

Table 2 provides some indication of the nature of the constraints generating the division between households[49]. The 'switching' equation corresponds to Equation (17), indicating the impact of the explanatory variables on the probability of being in Regime 1 and therefore the probability of being constrained[50]. First of all, we reject the null hypothesis in favour of hypothesis 4: participation in the programme significantly reduces the probability of being constrained. The results suggest that in addition to participation in the SLCP, household education (*education*), family size ($famsize$), as well as development of land transfers (*rent*) and better soil quality (indicating more secure tenure) reduce the probability of being constrained, as does living in the Guizhou region. Conversely, arable land endowment (*land*), distance to the nearest road (*distroad*) and to the nearest credit agency (*credit dist*), presence of children under 16 and elderly members of the household (*child* and *elderly* respectively) increase the probability of being in the constrained regime. The results show that there are a number of important market failures and transactions costs underpinning the constrained households.

As seen elsewhere in China, inadequate access to credit, difficulties in land rental and insecure tenure are prominent market and institutional failures in the areas in question[51]. The effect of the area of cultivated land (*land*) further points to a link between off-farm labour supply and the constraints imposed on households behaviour by imperfect land

[49] These are robust standard errors.

[50] Note, the coefficients do not represent pure marginal effects on the probability.

[51] e.g. Carter and Yao (2002), Deininger and Jin (2003), Bowlus and Sicular (2003), Feder et al (1990).

Regressors	Coefficient	(s.e)
'Projection' variables		
Year	-0.1	0.08
Participation	-2.1***	0.07
Treatment Effect		
Treat	-0.4***	0.09
Other Variables		
Land	0.1***	0.001
Education (log)	-5.2***	0.06
HH size	-0.6***	0.01
Region	-1.2***	0.04
Constraint Variables		
Elderly	1.7***	0.08
Child	0.2***	0.04
Credit access	0.1***	0.004
Rentease	-0.06	0.06
Soilquality	-2.2***	0.04
Distance (log)	0.1***	0.01
Constant	7.1***	0.16
F-Stat (p value)	1651.8 (0.000)	
Observations	322	

Table 2: Switching Equation

rights. Indeed, the rather surprising fact that more land *increases* the probability of being constrained (*land* has a positive coefficient in the switcher equation) confirms that having more land increases the burden of constraints and compels households to attach more labour to cultivation. As a consequence, the availability of labour for more lucrative off-farm opportunities is reduced, as illustrated by the impact of land rental rights on such constrained households' off-farm labour supply. Here, more developed land rights decrease the probability of being constrained, hence contributing to allow households to supply freely their labour off-farm and enhance the efficiency of their labour allocation choices (Carter and Yao 2002). The impact of the presence of young children or elders, which increases the probability of being in the constrained regime, reflects the fact that it is traditional in China (and imposed by the lack of a social security system) for care for the elderly to provided by younger family members[52].

5.4 Regime characteristics

Predictions from the 'switcher' equation yield the probability that a household belongs to a particular regime and allows us to identify constrained and unconstrained households in the sample[53]. Comparing the characteristics of constrained versus unconstrained households points to policy recommendations related to programme targeting, and allows to check that no single source of constraints determines sample separation. Confirmation of the last point

[52]Many households in our survey cited care for the elderly as an important constraint to finding off-farm labour.

[53]We define constrained households whose probability of being in the constrained regime is greater that the mean probability in the sample: 0.66.

validates the use of a switching regression, one of the main advantages of which is that it does not confine the source of constraint to any specific institutional or market failure[54]. As we can see from Table B2 in Appendix B constrained households differ significantly from unconstrained households in many respects. This indicates that no single variable drives the partition of the sample, and this confirms our motives for using the switching regression. Constrained households supply significantly less off-farm labour, are more likely to live in Ningxia, have a larger land endowment, exhibit lower levels of education and are further from main roads and formal credit agencies. These households are also more likely to live with young children and pensioners than unconstrained households. The institutional environment of these two groups of households also differs significantly. Rental rights are more likely to be prohibited and soil quality to be lower (indicating less tenure security), for those households that are identified as being constrained. However, the propensity of participating in the SLCP does not significantly vary across groups. This may signal that the targeting of the SLCP was inadequate, as is further discussed in the conclusion.

6 Conclusion

The results show that the SLCP has a heterogeneous impact on different groups of households, which face market and institutional failures of different types and intensities. When controlling for this heterogeneity, we are able to show that the SLCP induces

[54]Feder et al. (1990) use only the credit constraint as a source of behavioral difference, Carter and Yao (2002) focus on the land exchange rights, Bowlus and Sicular (2003) consider only the differences in land endowments or the development of the off-farm labour market, in exclusion of each other.

participating households to reallocate a substantial amount of labour towards off-farm employment. Moreover, participation in the SLCP reduces households' exposure to constraints. The empirical evidence indicates that the SLCP induces a win-win outcome via the relaxation of constraints. Participants in the SLCP are enabled to access additional income enhancing opportunities off-farm and the incentives for environmentally harmful allocation choices are reduced. This optimistic result should be tempered by the fact that the SLCP is limited in the extent to which it relaxes constraints. Indeed, participation in the SLCP has no statistically significant impact on the supply of labour to the most lucrative off-farm activities, i.e. outside the village.

Three main conclusions and policy implications can be derived from this analysis. Firstly, our methodology and results highlight the importance of accommodating heterogeneity in the evaluation of interventions in a context where households face idiosyncratic institutional and market failures. Applying traditional policy evaluation methods, which treat all households as a homogeneous group, would here yield erroneous policy implications. This is demonstrated in column 2 of Table 1, which indicates that a global policy approach confounds the impact of the programme and would lead us to conclude that the impact of the SLCP on off-farm labour supply was insignificant. As a matter of fact, no previous evaluation of the SLCP has revealed any significant impact of the SLCP on off-farm labour supply, and yet each acknowledges that the sustainability of the programme rests upon its ability to enable households to access alternative employment opportunities (Uchida et al., 2005; Xu et al., 2004) . Our study is the first to point to a significant impact of the SLCP on households' off-farm labour supply decisions, albeit only

on labour supplied by constrained households within the village in Ningxia.

Secondly, our analysis brings important policy recommendations with respect to programme targeting. The results imply that in order to improve the cost effectiveness of the programme subsidies should target constrained households. This is a common problem for poverty alleviation programmes (Besley and Kanbur 1988). The analysis of the characteristics of the constrained and unconstrained households, as identified by the switching equation in Table B2, leads us to conclude that the programme should focus not only on households with large land endowments, as is currently the case, but should also consider the education level, household structure and the institutional environment of recipient households. The compensation package offered by the SLCP in its current design is much too uniform: it only accounts for two different levels of grain subsidy, and this distinction is made only on the basis of gross regional averages, and not at all on the basis of households characteristics. However, a more flexible design on the basis of household and land characteristics may give way to manipulation, either by individual households, or by local authorities. Xu et al. (2004) namely reveal that the simplified current compensation scheme was implemented by the Central Government in part to counter rent seeking behaviour of local government that may be tempted to exploit their informational advantage by exaggerating estimates of opportunity costs so as to inflate the level of subsidies. Targeting the programme on households characteristics may, thus, be complicated and costly. However, the results here indicate two potential improvements to the current situation. Firstly, policy design should embody adequate screening mechanisms to counter issues of adverse selection. For example, introducing work requirements for

programme participants could induce constrained households to self select in the programme (Besley and Coate 1992). The SLCP arranges for such requirements on tree planting and maintenance, but this clause was often misused by local authorities: ad-hoc teams were appointed which diverted programme subsidies away from SLCP participants (Xu et al. 2004). Secondly our analysis suggests that the objectives of the programme could be furthered, achieved more efficiently, by addressing institutional constraints such as the development of land rentals, tenure security or access to credit. These constraints remain the major impediments to labour reallocation and drive important behavioural differences between constrained and unconstrained households. The last implication of our analysis is thus that accompanying policies should focus on such constraints.

In this regard, Chinese central authorities appear to be moving in the right direction. Indeed, the National Peoples Congress announced in March 2005 that all agricultural taxes were to be removed by 2006[55]. Also, the Hukou registration system will be lifted in 11 regions, which will facilitate migration to cities[56]. Concerning institutional constraints, in 2002, the National People's Congress adopted the Rural Land Contracting Law, which reaffirmed rural households' land use rights and their rights to transfer, exchange, and assign their land use rights to other households (Wang, Han and Bennett 2004). Nevertheless, how these changes and reforms will affect the rural poor depends greatly on the implementation will and capacity of local authorities.

[55]Source: People's Daily Online, March, 05, 2005; China Daily, March, 06, 2005.

[56]Source: China Daily, 25/11/05; BBC 10/11/2005.

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Appendices

A Household Model

The first order conditions of the maximization problem defined by (1) are:

$$l^0 : U_1(.)w^o - U_2(.) = 0 \tag{19}$$

$$l^i : U_1(.)pq_1(.) - U_2(.) + \mu^c q_1(.) = 0 \tag{20}$$

$$\theta : -U_1(.)pq_2(.) - \mu^c q_2(.) + \mu^\theta = 0 \tag{21}$$

$$\mu^c : \mu^c C - q(l^i, \bar{\theta} - \theta, z^q) = 0, \mu^c \geq 0, C - q(l^i, \bar{\theta} - \theta, z^q) \leq 0 \tag{22}$$

$$\mu^\theta : \mu^\theta \theta_0 - \theta = 0, \mu^\theta \geq 0, \theta_0 - \theta \leq 0 \tag{23}$$

where μ^c and μ^θ are the Lagrange multiplier associated with the constraints (2) and (3) respectively, and: $U_1(.) = U_1(p, w^o, l^i, \bar{\theta}, \theta, z^q, T, l^o, z^c)$ and $U_2(.) = U_2(p, w^o, l^i, \bar{\theta}, \theta, z^q, T, l^o, z^c)$ are the marginal utilities of income and leisure respectively while $q_1(.) = q_1(l^i, \bar{\theta} - \theta)$, and $q_2(.) = q_2(l^i, \bar{\theta} - \theta)$ are the marginal productivities of labour and land respectively.

When neither the farm output (2) nor the land (3) constraint is binding, the first order conditions of utility maximization write as:

$$l^o : U_1(.)w^o - U_2(.) = 0 \tag{24}$$

$$l^i : U_1(.)pq_1(.) - U_2(.) = 0 \tag{25}$$

$$\theta : pq_2(.) = 0 \tag{26}$$

Here, the household equalizes the returns of on- and off-farm labour, and cultivates land until the marginal productivity of labour on that land meets the off-farm wage. Let us designate by $\hat{\theta}$ the productivity of the marginal land under cultivation such that the marginal productivity of on-farm labour equals the off-farm market wage. Using (24) and (25), $\hat{\theta}$ is such that:

$$w^o = pq_1(l^i, \bar{\theta} - \hat{\theta}, z^q) \tag{27}$$

and

$$pq_2(l^i, \bar{\theta} - \hat{\theta}, z^q) = 0 \tag{28}$$

Solving (27) for l^i brings a reduced form equation where l^i depends only on production side characteristics and can, hence, be defined as separable (Singh et al. 1986):

$$l^i = f(p, w^o, \bar{\theta}, \hat{\theta}, z^q) \tag{29}$$

Using (27), (24) and (25), we can obtain the following reduced form equation for l^o :

$$l^o = f(p, w^o, \bar{\theta}, \hat{\theta}, T, z^q, z^c) \tag{30}$$

When only the land constraint (3) is binding, the first order conditions of utility maximization rewrite as:

$$l^0 : U_1(.)w^o - U_2(.) = 0 \tag{31}$$

$$l^i : U_1(.)pq_1(.) - U_2(.) = 0 \tag{32}$$

$$\theta : -U_1(.)pq_2(.) + \mu^\theta = 0 \tag{33}$$

$$\mu^\theta : \theta = \theta_0 \tag{34}$$

Here, combining (31) and (32) shows that the household still equalizes the returns of on- and off-farm labour:

$$w^o = pq_1(l^i, \bar{\theta} - \theta_0, z^q) \tag{35}$$

In other words, separability between on farm production decisions and consumption decisions holds and the household supplies off-farm labour such that the marginal utility of income is equal to the marginal utility of leisure. However, the reduced form of off-farm labour supply becomes:

$$l^o = f(p, w^o, \bar{\theta}, \theta_0, T, z^q, z^c) \tag{36}$$

One important difference compared to the first group of unconstrained households is that the land decision is a corner solution and off-farm labour supply depends on the land constraint, θ_0[57].

[57] This last category of household, for which the land constraint is binding is likely to be more representative

Let us now consider the behaviour of households for which the farm output constraint is binding. To see how such households are also submitted to the land constraint, consider (19) to (23). If the production constraint is binding, we have $\mu^c > 0$. Looking at (21), if $\mu^c > 0$, then μ^θ must also be strictly positive for (21) to have a solution. Therefore, if the production constraint is binding, the land constraint is also binding, that is, households use all land that is available to them. When both the production and the land constraints are binding, the first order conditions for utility maximization can be rewritten as:

$$l^o : U_1(.)w^o - U_2(.) = 0 \tag{37}$$

$$l^i : U_1(.)pq_1(.) - U_2(.) + \mu^c q_1(.) = 0 \tag{38}$$

$$\theta : -U_1(.)pq_2(.) - \mu^c q_2(.) + \mu^\theta = 0 \tag{39}$$

$$\mu^c : q(l^i, \bar{\theta} - \theta, z^q) = C \tag{40}$$

$$\mu^\theta : \theta = \theta_0 \tag{41}$$

Agricultural production of the household is entirely determined by (40). Using (41) and (40) we can solve for a reduced form equation for l^i expressed as a function of the constraints and the production shifters only:

of our sample than the households for which the land constraint is not binding. On average we observe that all land is cultivated. Indeed, the average endowment of arable land of participants in the SLCP is 17.8 mu. Before the beginning of the program, on average, 17.6 mu were cultivated. This figure drops to 6.64 mu in the current period. The difference corresponds to the amount of land enrolled in the SLCP (on average, 12.44 mu). Non SLCP participants are endowed with 11.3 mu of arable land on average. The average cultivated areas before the program and in the current period are however almost identical, respectively 10.6 and 10.2 mu.

$$\bar{l}^i = f(C, \bar{\theta}, \theta_0, z^q) \tag{42}$$

From (37) and (38), we can infer that the household is neither able to equalize the returns of off-farm labour to the off-farm market wage, nor to equalize the returns of on- and off-farm labour. In this case the market wage for off-farm labour is equated to the following term:

$$w^o = pq_1(.) + \mu^c \frac{q_1(.)}{U_1(.)} \tag{43}$$

where $q_1(.) = q_1(\bar{l}^i, \bar{\theta} - \theta_0, z^q)$, and $U_1(.) = U_1(p, w^o, l^o, C, T, \bar{\theta}, \theta_0, z^q, z^c)$. Consequently, the decision price for labour allocation becomes a shadow price, which is lower than the market wage w^o.

The off-farm labour supply of the off-farm constrained household is given by the reduced form equation for l^o:

$$l^o = f(p, w^o, C, T, \bar{\theta}, \theta_0, z^q, z^c) \tag{44}$$

B Description of Explanatory Variables and Regime Characteristics

	Variable	Survey Source	Mean	Std. Dev.
Off Farm Labour	Hshld off-farm labour supply (hrs)	Household	380.1	284.6
Region	=1 if Guizhou	Household	0.44	0.50
Outdum	=1 if work outside village	Household	0.68	0.46
OutPRE	=1 if work outside village pre SLCP	Household	0.70	0.48
OutPOST	=1 if work outside village post SLCP	Household	0.65	0.45
Treat	Treatment	Household	0.38	0.49
TreatReg	Treatment * Region	Household	0.17	0.37
TreatOut	Treatment * Work out of village	Household	0.26	0.44
Land	Arable land (mu)	Household	15.8	15.5
Education	Hshld education level per capita (yrs)	Household	2.29	0.93
HH size	Household Size	Household	5.29	1.59
$(\text{HH size})^2$	Household Size Squared	Household	30.5	20.3
Elderly	=1 if hshld has elderly members	Household	0.11	0.32
Child	=1 if hshld has children	Household	0.46	0.50
Rentease	=1 if land rental unrestricted	Village	0.80	0.40
Credit access	Dist to formal credit institution (km)	Village	5.45	4.32
Soil Quality	Degree of soil erosion	Village	0.34	0.47
Distance	Dist to nearest town in (km)	Village	4.87	3.95

Table B1: Descriptive Statistics

	Constrained		Unconstrained		Unconstrained-Constrained		
Variables	Mean	s.d	Mean	s.d	Difference	t-stat	p-value
OffLabour	302.3	18.7	433.4	22.7	131.1	4.6	0.0
Region	0.2	0.03	0.6	0.04	0.4	8.5	0.0
Treat	0.3	0.04	0.4	0.04	0.09	1.7	0.09
TreatReg	0.05	0.02	0.2	0.03	0.2	5.5	0.0
TreatOut	0.3	0.04	0.3	0.03	0.01	0.09	0.9
Outdum	0.63	0.46	0.73	0.55	0.01	1.9	0.05
Land	23.6	1.8	10.4	0.6	-13.2	-7.2	0.0
Education	1.9	0.048	2.5	0.08	0.6	6.6	0.0
HH size	5.3	0.1	5.2	0.1	-0.1	-0.5	0.6
Elderly	0.2	0.03	0.07	0.02	-0.1	-2.8	0.01
Child	0.6	0.04	0.4	0.04	-0.2	-2.7	0.01
Rentease	0.7	0.04	0.9	0.02	0.2	4.1	0.0
Credit access	7.0	0.4	4.5	0.3	-2.6	-4.9	0.0
Soil Quality	0.2	0.04	0.4	0.04	0.2	3.5	0.0
Distance	5.9	0.4	4.2	0.3	-1.7	-3.6	0.0

Table B2: Comparison of Constrained and Unconstrained Households