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The effects of a subsidy for grassland protection on livestock numbers, grazing intensity, and herders' income in inner Mongolia

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ABSTRACT

Primary data from 262 pastoral households in Inner Mongolia are analyzed to determine the effects of a subsidy for grassland protection on livestock numbers, grazing intensity, and herders' income. Econometric models are estimated to determine the effects of the subsidy on each component of the intensity ratio (sheep-equivalent livestock units and grassland). Results suggest the subsidy increased the quantity of grassland controlled by the household. However, the effects on livestock units are mixed, with two of the four studied prefectures (Ordos and Ulanqab) showing a positive response, and two (Hulunbuir and Xilingol) showing a negative response. Inserting the parameter estimates from the livestock, grassland, and income functions into a structural model of grazing intensity, results suggest each 1% increase in subsidy reduces grazing intensity by between 0.168% and 0.532% depending on the prefecture, and increases herders' income by between 0.144% and 0.670%. By way of comparison, each additional year of education increases herders' income by 8.7% and reduces grazing intensity by 3.6%. Thus, education is not to be overlooked as a policy tool for achieving conservation goals.

1. Introduction

In semi-natural and managed rangelands, livestock grazing is a widespread and dominant land-use activity (Fleischner, 1996; Zhao et al., 2005; Han et al., 2008; Harris, 2010). Continuous heavy grazing causes soil surface disturbance, vegetation cover reduction, and rangeland degradation (Johnston et al., 1971; Brown and Mcdonald, 1995; Curtin, 2002; Pakeman et al., 2003; Kemp et al., 2012; Yang et al., 2012; Hao et al., 2014). Grazing control is a necessary component of grassland management (Hulme et al., 1999; Schönbach et al., 2011). It can be used to harmonize potentially conflicting land use objectives, or to emphasize a particular objective within a given management regime (Grant et al., 1996). The benefits of grazing control and reduced grazing intensity are supported by a large body of research on grassland restoration (e.g., Owen, 1977; Gibson et al., 1992; Smith et al., 1996; Leriche et al., 2001; Tallowin et al., 2005; Marriott et al., 2009). Reducing livestock numbers or increasing the efficiency of livestock production has the potential to reduce methane emissions and increase the ability of grasslands to sequester carbon (Kemp et al., 2012).

A growing body of research suggests rangeland degradation is a long term and large scale environmental problem in China, especially in the Northern and Northwestern provinces of Xinjiang, Qinghai, Gansu, Ningxia, and Inner Mongolia (Banks, 2001; Meyer, 2006; Ho and Azadi, 2010; Wang et al., 2013; Kolås, 2014). Identifying strategies that restore the ecosystem functions of grassland while at the same time improving the livelihoods of traditional pastoralists pose a major challenge for policy makers (Han et al., 2008; Brown et al., 2011; Kemp et al., 2012; Waldron et al., 2011; David et al., 2013; Li et al., 2014).

To protect and restore ecosystems China has implemented several conservation programs. The "Grain-for-Green" program initiated in 1999 and widely implemented in 2003 is perhaps the most notable program. Its primary aim was to convert marginal farmland to forest and grassland (State Council of China, 2002; Feng et al., 2005). In terms of Inner Mongolia, the Beijing-Tianjin sandstorm source control project initiated in 2001 is notable. Its aim was to

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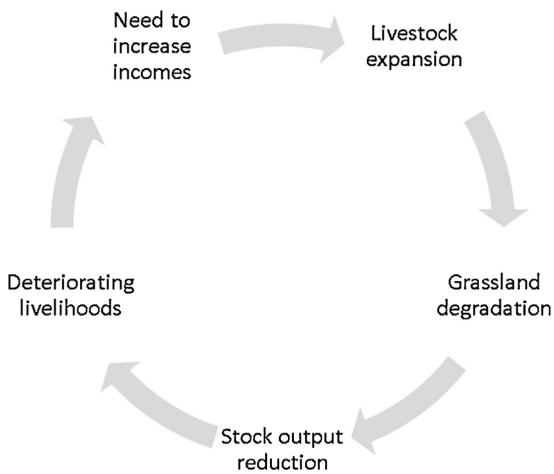

Fig. 1. Vicious cycle in increasing herder's income.
Source: Li et al. (2014).

build a greenbelt north of Beijing (Jiang, 2006; Yeh, 2009; Wang et al., 2013). Even more significant, however, is the "Grazing Control and Grassland Protection Subsidy Program" initiated in 2011 (State Council of China, 2011; Hua and Squires, 2014; Zhen et al., 2014; Hu et al., 2015). This program uses subsidies as an incentive to control livestock numbers and reduce grazing intensity. China's central government is projected to spend $2.14 billion on the program over five years, of which $0.65 billion is allocated for Inner Mongolia starting in 2011.[1]

The purpose of this research is to determine the effects of the subsidy program on livestock numbers, grazing intensity, and herders' income. A secondary purpose is to determine the extent to which the vicious-cycle hypothesis set forth by Li et al. (2014) applies to Inner Mongolia. This hypothesis asserts that herders respond to decreased productivity of their grasslands associated with overgrazing by increasing livestock numbers in a bid to maintain living standards. The resulting increase in stocking rates degrades further the grassland, and the cycle repeats itself (see Fig. 1). The vicious-cycle hypothesis implies that grassland in the first instance is overgrazed.[2] If this is true, an increase in grazing intensity should reduce herders' income at the margin. We test this hypothesis by estimating a structural model of herders' behavior that includes income as one of the equations.

Previous research has been useful in documenting the environmental consequences of rangeland degradation in China (e.g., Banks, 2001; Meyer, 2006; Ho and Azadi, 2010; Kemp et al., 2012; Wang et al., 2013), and in indicating the potential benefits of grazing control and reduced grazing intensity on grasslands and the ecosystem (e.g., Owen, 1977; Gibson et al., 1992; Smith et al., 1996; Leriche et al., 2001; Tallowin et al., 2005; Marriott et al., 2009; Kemp and Michalk, 2011). Studies specific to Inner Mongolia document the effects of sandstorm control and other government policies on *inter alia* grassland restoration (Jiang, 2006; Yeh, 2009; Wang et al., 2013). This study fills a gap in the literature by quantifying the effects of the subsidy program on herders' behavior as it relates to four key variables; namely, livestock numbers, grassland holdings, grazing intensity, and income.

The paper is organized as follows. Section 2 presents the theoretical framework for the analysis. Sections 3 and 4 describe the data, empirical model, and regression results. Section 5 presents and interprets the reduced-form elasticities estimated from the model. Section 6 concludes.

2. Theoretical framework

2.1. Structural model

Imagine a household that grazes Q units of livestock on GL units of grassland. To encourage conservation, the government provides the household that follows specified conservation practices a subsidy equal to S. Grassland controlled by the household is a function of the subsidy, but also the household's income level Y. The subsidy influences Q indirectly through its effect on GL, but also directly through its effect on the expected profitability of the livestock enterprise. The income received by the household is a function of livestock numbers and grazing intensity.

With these assumptions, the equations describing the household's response to the subsidy may be written as follows:

$$\mathrm{Q} = \mathrm{f}\left(GL, \bar{S}\right)\left(\partial Q/\partial GL > 0, \partial Q/\partial S < 0\right) \quad (1)$$

$$\mathrm{GL} = \mathrm{g}\left(Y, \bar{S}\right)\left(\partial GL/\partial Y > 0, \partial GL/\partial S > 0\right) \quad (2)$$

$$\mathrm{Y} = \mathrm{g}\left(Q, I\right)\left(\partial Y/\partial Q > 0, \partial Y/\partial I > 0\right) \quad (3)$$

where the overbar ($\bar{\square}$) denotes an exogenous variable. Livestock units are an increasing function of grassland, and the grassland controlled by the household is an increasing function of income. The subsidy provides incentives to increase land holdings, but also imposes compliance costs. Thus, livestock units are a decreasing function of subsidy, and grassland is an increasing function of subsidy. Income is an increasing function of livestock units and grazing intensity. The structural model is completed with an identity that defines grazing intensity

$$I = Q/GL. \quad (4)$$

The model consists of four endogenous variables (Q, GL,Y, I) and one exogenous variable ($\bar{S}$). Other exogenous variables that affect the equilibrium levels of livestock, grassland, and income are suppressed. Of key interest is the effect of an increase in the subsidy on grazing intensity and herders' income given the posited relationships.

To determine that, first write the model in proportionate change form

$$Q^* = \alpha_{GL} GL^* + \alpha_S \bar{S}^* (\alpha_{GL} > 0, \alpha_S < 0) \quad (5)$$

$$GL^* = \beta_Y Y^* + \beta_S \bar{S}^* (\beta_Y > 0, \beta_S > 0) \quad (6)$$

[1] Payments under the program are to be provided for (i) grassland where grazing is no longer permitted; (ii) maintaining a favorable forage-livestock balance; (iii) selected animal husbandry practices such as growing superior seed; and iv) production material (such as purchases of new equipment). To be eligible for the subsidies the household is required to reduce livestock to a preset level depending on herd size. In areas where livestock are numerous, households are given five years to comply with the specified reduction; in other areas compliance must be accomplished within three years. There are certain restrictions on the subsidies. For example, in the case of animal husbandry practices, if the household keeps grassland in the same situation as before 2010, first- and second-year subsidies are limited to $23.88/ha. Subsidies for one-year practices like growing superior seed are $35.82/ha, and for new forage shrubs is $23.88/ha (DAIM, 2011).

[2] In his review of the literature, Harris (2010) identifies seven "putative drivers" of rangeland degradation in northern China: an inherently harsh climate and fragile soils, global climate change, damage by "rodents," unsustainable conversion of rangelands to cultivated crops, "backward" pastoral production systems, privatization and/or sedentarization (including fencing), and overstocking. In assessing the evidence adduced for each driver, Harris concludes that cause and effect has not been established for any of them, including overstocking. A basic reason is that studies often fail to cast their analyses in the form of hypotheses to be tested, or do so in such a vague manner as to preclude valid inferences about causal mechanisms. Until the science improves, Harris argues that even assertions about the extent of grassland degradation in China (commonly cited to be some 90% of all grasslands) must be treated with caution. This caution motivates our testing the vicious-cycle hypothesis, as it is possible that overstocking per se is not an issue in Inner Mongolia.