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Forest Policy and Economics 1 (2000) 27–40

Forest Policy  
and  
Economics

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## Impacts of economic reforms on rural forestry in China

Yaoqi Zhang<sup>a,\*</sup>, Jussi Uusivuori<sup>b</sup>, Jari Kuuluvainen<sup>a</sup>

<sup>a</sup>*Department of Forest Economics, 00014 University of Helsinki, Finland*

<sup>b</sup>*Finnish Forest Research Institute, 00710 Helsinki, Finland*

Received 10 September 1999; received in revised form 18 January 2000; accepted 31 January 2000

### Abstract

This paper addresses the effects of economic transition policies on forestry in China. The effects of de-collectivization and market liberalization on the forest land area and timber harvest are studied using panel data from four provinces covering the period 1978–1995. Fixed effects ordinary least squares models for forest land cover and annual harvests per hectare are estimated, allowing for differences across provinces and prefectures in northern and southern China. The results show that land tenure reform in general has had a positive effect on forest land expansion, but the absolute size of the effects varies from province to province. The positive impact of the reform on timber harvesting has not taken place at the cost of forest land cover. The claim that market liberalization leads to over-harvesting of forest resources in developing countries is not supported by our results. © 2000 Elsevier Science B.V. All rights reserved.

*Keywords:* China; Economic reform; Forestry; Market; Land tenure

### 1. Introduction

Institutions controlling land tenure, the degree of competition in the timber market and forest owners' access to this market have fundamental impacts on the extent and intensity of forest

management. These issues are of current interest in developing countries and other economies in transition. Both land tenure and market reforms have been widely discussed as means of promoting sustainable forest management.

In the land tenure issue, two related aspects can be distinguished: security of land tenure and land ownership categories. Mendelsohn (1994), Deacon (1994), Besley (1995) and Laarman (1996) all suggested that secure land property rights provide an incentive for efficient forest manage-

\* Corresponding author. Tel.: +358-9-1917748; fax: +358-9-1917729.

*E-mail address:* yaoqi.zhang@helsinki.fi (Y. Zhang)

ment. As regards the effects of land ownership categories, research findings are more divided concerning the effects of different types of ownership. Wallace and Newman (1986) found that ownership categories affected forest management productivity, as measured by timber growth plus removal in North Carolina in the United States. According to Zhang (1996), forest tenure significantly affected land value in British Columbia in Canada. Place and Otsuka (1997) showed that land privatization had promoted forest investment in some African countries, while Powell (1998) suggested that communal land tenure should be preferred to 'modern' systems of private land ownership in the South Pacific. Palo (1994) claimed that a certain minimum share of privately owned forests in a country is necessary to support competitive timber markets and sustainable forestry. Demsetz (1967) and Alchian and Demsetz (1973) described the nature and evolution of the property rights issue in general. Bromley (1989) and North (1998) argued that privatization programs should be designed and evaluated broadly within the given institutional framework of the region in question.

The market mechanism is another instrument that is important for forest management. A widely held hypothesis is that an improvement in market conditions, especially in developing countries and economies in transition, will make forest investments more attractive and increase the efficiency of forest management. Hyde and Seve (1993) and Hyde et al. (1996) found some evidence that rising timber prices had led to an increase in forestry investments in Malawi, Kenya and Chile. However, rising timber prices alone are only a weak incentive when the institutions that govern timber markets, taxation and subsidization policies are poorly developed and lack information transparency and a well functioning credit market.

In this study we explore the impacts of rural reforms on forestry in China, both those related to land tenure and those related to timber market reforms. We focus on the determinants of forest land allocation and timber harvests during China's transition to a more market oriented economy. During the transition years, China has undergone

changes in land tenure involving a shift from state and collective ownership to more privately oriented land tenure. At the same time, liberalization measures have been implemented in rural markets for materials, labor, agricultural products and timber.

There is an increasing body of literature on the effects of economic reforms on the agricultural sector. McMillan et al. (1989), Lin (1992) and Wen (1993), among others, universally claimed that de-collectivization was the major reason for the growth of agricultural output in China from the late 1970s until the early 1980s. There are also studies on the impacts of land tenure change and other economic reforms on forest management. However, these studies on forestry, unlike those dealing with agriculture, are divided in terms of the effects of the reforms. Dong (1987), Xu (1987), Li (1997), Ruiz-Peres et al. (1996) advocated de-collectivization, Wu and Lin (1994) and Song et al. (1997) favored more moderate reform, e.g. a share holding system, while Di (1994) takes a more conservative view as regards the role of reform in rural forestry development in China. Yin and Newman (1997) argued that the different impacts of reforms in different districts reflected the different ways in which the general policy was implemented. They suggested that in southern China, where the reforms have been less consistent and less predictable than in northern China, developments in forestry had been less favorable than in the northern rural areas.

It is true that there are differences in the way and intensity in which nationwide economic reforms have been implemented in various parts of the country. However, these differences may not be limited to those between northern and southern China. There is also variation in the extent and style of policies across provinces and even across prefectures level. In addition, there are significant regional differences in the structure of forest resources, which also have consequences for the effects of policies between the regions.

We use an up-to-date prefecture level panel data set consisting of the annual observations from the period 1978–1995 to analyze the impacts of the economic reforms on forest land allocation and timber harvests. The contribution of this study

is to estimate a theoretically justified reduced-form equation for forest land and a rural farmers' timber supply equation. The directly unobservable differences at prefecture level are taken into account in order to avoid the omitted variables bias in the estimated effects of privatization, prices and costs on forest cover and annual harvests. Privatization generally promotes both land allocation to forestry and timber harvest without any signs of adverse effects of mining type harvesting operations.

## 2. Chinese rural forestry and economic reform

China has four geographically distinct forest regions (southeast/south-central, north-central, northeast and southwest) and two different land ownership categories (state-owned and collective-owned). Zhang et al. (1999) summarized the differences between these four regions. The north-

east and southwest are dominated by state-ownership and natural forests. The southeast/south-central and north-central areas are dominated by collective ownership.

In this study we focus on rural forestry, which is mainly located in the southeast/south-central (hereafter the south) and north-central areas (hereafter the north). In these two regions, approximately 90% of forestry land is managed by rural farmers, under various collective or household management arrangements with the general framework of collective forestry land ownership (see Fig. 1).

The forests and natural conditions differ considerably between the south and the north. The south, where the landscape is dominated by mountainous ranges and forest cover, was a traditional timber supply region and is currently the biggest wood producer in China. Natural forests and plantation forests coexist, although the natural forest has been gradually transformed into

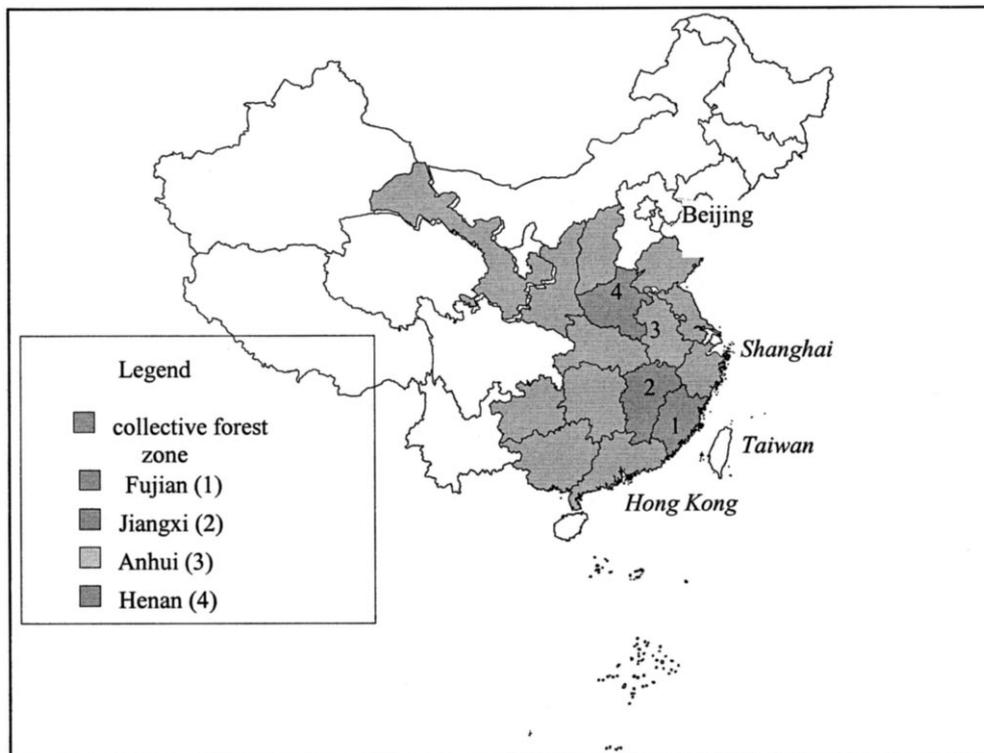


Fig. 1. The collective forest area and four selected provinces.

plantation forest. In contrast, the north is flat and has a higher share of arable land, a higher population density and a longer agricultural history. The economy is dominated by farming, whereas forestry has only a minor role in the economy, but is nevertheless critical for the environment.

Historically, land tenure did not differ very much between the south and the north. Before 1949, the forests and land were owned by private landlords, merchants and self-sufficient farmers. Some remote sites were common or open access land.

The *Land Reform* implemented in 1950–1956 confiscated all land owned by landlords and distributed most of it to local rural farmers, while the rest was placed under state ownership. The ensuing *socialistic movement* transferred all land from individuals to the collectives (e.g. villages) in the first phase of collectivization, and further to the *people's communes* (usually several villages combined together to form one commune) in the second phase. Here we should note that collectively owned forestry land is not usually open access land (see also Bromley, 1989), and in fact is quite similar to community forest in some other countries. But in conditions where either the authority of the collective is weak or administration is ineffective, some of the land does in fact become land to which the people in the community have open or semi-open access, at least for a certain period of time.

The *economic reform* started in rural areas in

the late 1970s, although trials were carried out with the household responsibility system (HRS) and privatization in agriculture before then. After Mao's death in 1976, the political environment was not as tightly controlled, and farmers from the poorest regions were able to initiate changes without the central government being aware of them. Later, these changes received the blessing of local authorities, and were finally officially accepted in 1981. By the end of 1983, approximately 98% of collectively owned agricultural land throughout the country had become part of HRS land (Lin, 1992), and agricultural reforms were generally successful.

For rural forestry, the reforms did not begin until 1980 and differed from region to region. De-collectivization has been implemented primarily by distributing forestry land evenly to households on the basis of the number of persons in the household and secondly by transferring management to contractors, who receive management rights together with some responsibilities from the collective authority. The contracts are made by simple negotiation or auction and the length of contact varies from place to place.

The extensity of land tenure change might be determined by the following factors: first, the interpretation of the general de-collectivization policy by local people, particularly local leaders, in cases where the central government did not give clear signals of its own intentions; second, the characteristics of the forest and land and

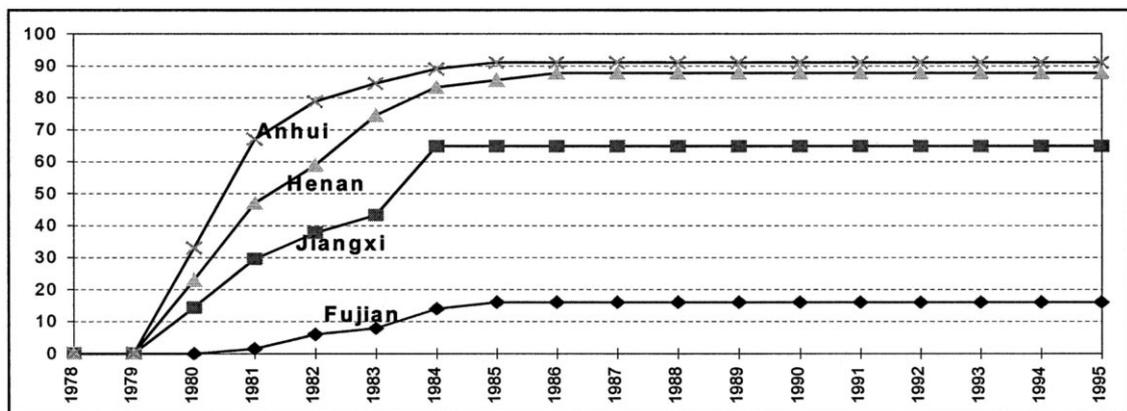


Fig. 2. The path of forestry land transfer to the HRS in the four selected provinces.

technical problems as regards fragmentation; and third, motivation and interest of local farmers, particularly local leaders, with regards to de-collectivization, and the local market mechanism and democratic status. Fig. 2 shows the time paths of de-collectivization as percentages of total land transferred from collective forest management to the HRS in the four rural forestry provinces. In the north (Anhui and Henan) the process was much quicker and more intensive than in the south (Fujian and Jiangxi) until the middle of the 1980s, when de-collectivization stagnated. In the south the difference between the two provinces is notable. There was also some variation across prefectures during the de-collectivization process.

A typical approach in regions where de-collectivization was slow (as in Fujian Province) was the so-called *share-holders' system* (Song et al., 1997). Several advantages were associated with this moderate reform approach: economies of scale, consistency without abrupt change, technical feasibility and political acceptability. The merits of this reform were demonstrated within a few years of its implementation. Consequently, this reform system has become the most popular throughout the country since the middle of the 1980s.

From the onset of the transition period in the late 1970s, the laissez-faire timber market policies applied in the north have differed greatly from the more regulatory policies in the south of China.

In the southern provinces, timber-selling licenses, quotas, and prices imposed by the timber procurement agencies were abolished only in 1985, then re-imposed in 1986 and abolished again in 1993 in the southern provinces. In the north, the higher timber price was a result of liberalization of the timber market and closeness to consumers (Fig. 3).

Along with the economic reform, the commodity price structure has undergone dramatic changes. Fig. 4 shows the deflated average prices for timber (including bamboo), agricultural goods purchased from farmers and rural industrial products purchased as inputs by farmers. In general, we can see that the timber price has increased more than that of agricultural goods, indicating the relative scarcity of timber supply. In recent years, the timber price seems to have fallen partly because of substantial timber production connected with the massive plantation programs and the changing domestic economic structure.

Timber harvests in the four provinces are depicted in Fig. 5. The north has experienced a larger relative increase in timber harvests than the south, especially in the 1990s, as the forests, which were largely planted in the 1960s and 1970s, have become mature, and demand, both domestic and foreign, was strong in the 1980s.

It is evident that both forest area and timber harvest have been affected by the reform policies

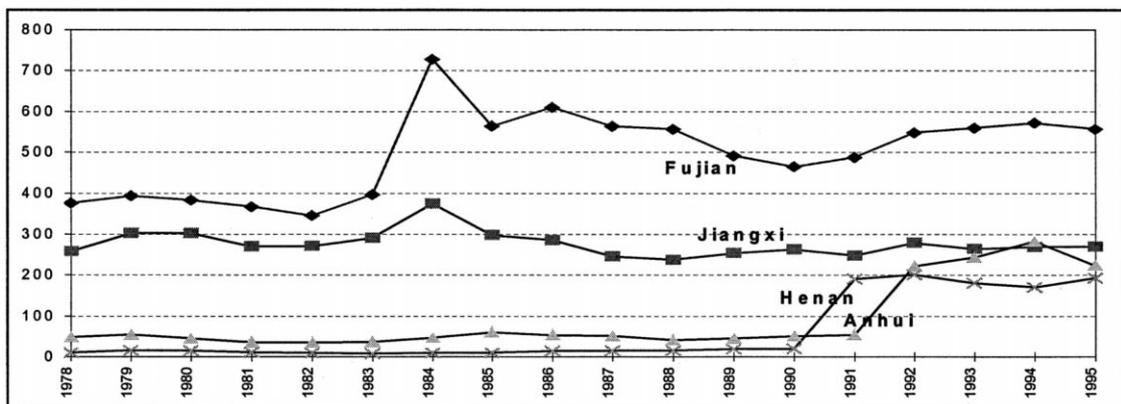


Fig. 3. Deflated timber price index in the four selected provinces.

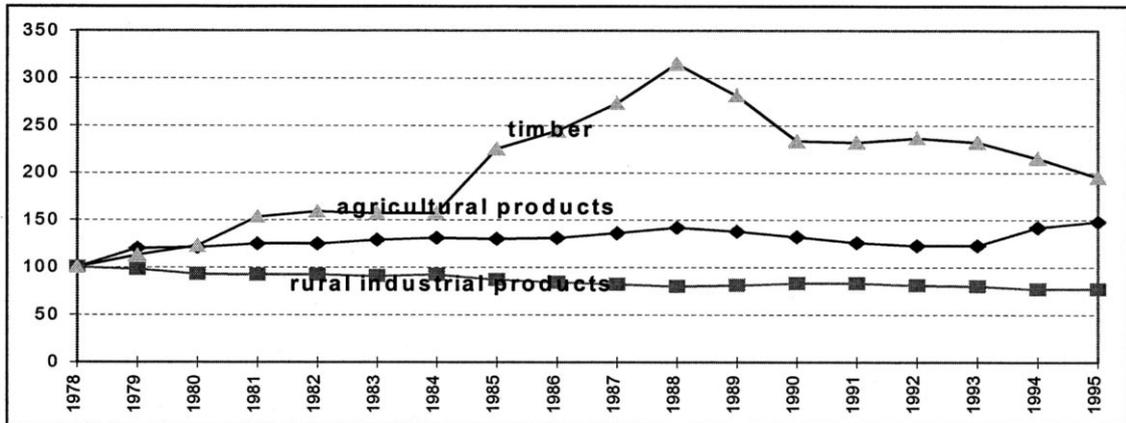


Fig. 4. Deflated price indexes for rural industrial products, agricultural commodities and timber.

initiated in the 1970s. This study attempts to contribute to the current understanding of these impacts through econometric analysis, to which we now turn.

### 3. Theoretical model for land allocation and timber harvesting in China

In this section we provide the theoretical framework for the estimable behavioral equations for the allocation of land to forest land and for timber harvesting in China. We derive the forest land<sup>1</sup> equation from a prefecture-level equilibrium model of forest land demand and supply, assuming that agriculture competes for land used in forestry. The timber harvest (supply) equation to be estimated at the prefecture level is based on a household production model of a representative forest owner with consumption and biomass harvesting (e.g. Max and Lehman, 1988; Amacher and Brazee, 1997). We include parameters describing policy instruments used in China to de-

collectivize land ownership and to liberalize rural markets in both the behavioral forest land demand and supply equations and in the timber supply equation.

#### 3.1. Equilibrium in the market for forest land

In modeling land use, it is possible to take either a spatial or a non-spatial approach. The spatial models emphasize the heterogeneous nature of land, such as soil quality, landscape slope and distance to markets. Landowners either adopt the highest-rent land use or rent or sell the land to someone else who will do so (see Chomitz and Gray, 1996). Usually higher soil quality and closeness to markets favor agriculture as opposed to forestry.

Following Panayotou and Sungsuwan (1994) and Cropper et al. (1999), who studied deforestation and agricultural land expansion in Thailand, we model forest land using a non-spatial equilibrium model that describes a prefecture-level demand for and supply of land for forest management. This leads to a reduced-form equation for the amount of land under forest management.

The equilibrium level of land allocated to forest management is determined by the demand for and supply of land. We hypothesize that the demand for forest management land is based on individual farmers' profit maximizing decisions. The competing land uses are assumed to be agri-

<sup>1</sup>Forest land in China is land with either a natural or established forest cover. Forestry land, on the other hand, is forest land and all idle land with a potential to become forested. Since approximately half of all forestry land is in a state of long-term fallow and consists of low biomass woodland, there is a great difference between these two concepts. In this article, we assume that only forest land, rather than the entire forestry land, is under active management.

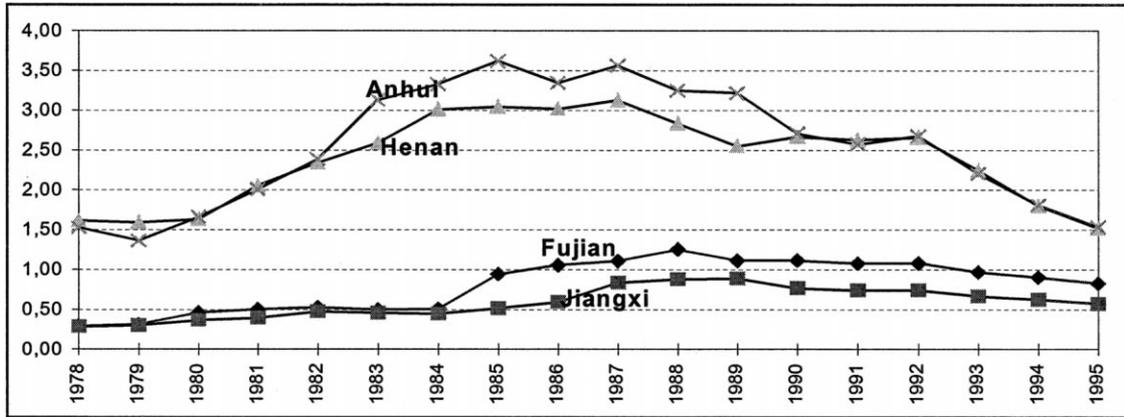


Fig. 5. Timber harvests in the four selected provinces. Note: unit: 1000 m<sup>3</sup>.

culture and forestry. In forestry, the relevant production function is defined for timber production. Although non-timber forest products have traditionally had an important role in China (see, e.g. Zhang et al., 1999), timber remains by far the most important income source from forests for Chinese farmers. Timber production,  $y$ , is considered to be a function of labor,  $L$ , capital,  $K$ , material,  $M$ , and forested land,  $FL$ . We also include a variable for the landowners' uncontrolled access to timber markets,  $DM$ , although its effect may be absorbed by prices and costs. The farmer's static profit maximizing problem in timber production is then given by:

$$\max_{L,K,M,FL} = PT \cdot y(L,K,M,FL,DM) - wL - rK - mM - p_{FL}FL, \quad (1)$$

where  $PT$  is the net price of timber,  $y()$  is the timber production function,  $w$ ,  $r$  and  $m$ , are, respectively, the wage rate, the rental rate on capital, and the unit cost of the material used for forest management.  $p_{FL}$  can be interpreted as 'exclusion cost' per unit of forest land, including the cost of establishing and protecting forest property rights. 'Exclusion cost' is often interpreted as one component of 'transaction cost' in the transaction cost economics that was originated by Coase (1937, 1960) and developed by Stigler (1966), Williamson (1975, 1985) and Barzel (1997), etc. It plays a critical role in determining active and non-active forest management for

forestry land in the developing countries and explains why a large share of forestry land remains idle. Therefore, transaction costs can be viewed as the cost of carrying out forest management activities.

Applying Hotelling's lemma and solving the first-order conditions for the input parameters in Eq. (1) yields the demand function for forest land:

$$D_{FL} = D(w,r,m,PT,p_{FL},DM). \quad (2)$$

As suggested by several authors (e.g. Wallace and Newman, 1986; Mendelsohn, 1994; Deacon, 1994; Place and Otsuka, 1997), land tenure conditions, which influence economic behavior, are an important factor for both the demand for and supply of forest land. Their impacts can be interpreted in different ways. As stated above,  $p_{FL}$  might be quite closely related to transaction costs. The Household Responsibility System (HRS) could be one of the most significant institutional changes. As we do not have direct information on  $p_{FL}$  we use the institutional variable,  $R$ , the per-

<sup>2</sup>Forestry land in China is defined as the land category which covers both forested land as well as land which is not farmed and is considered suitable for growing trees. Thus, for the allocation of this land between agriculture and forests, the HRS percentage within this land category is relevant. Unclear tenure favors either annual crops or non-active forest management, while, with more established tenureship, the relative attractiveness of forests increases.

centage of total forestry land under the HRS<sup>2</sup> in our model. Eq. (2) is transformed into Eq. (2'):

$$D_{FL} = D(w, r, m, PT, R, DM). \quad (2')$$

Within a prefecture, the smallest administrative unit supported by the data used in this study, the aggregate demand for forested land,  $D_{FL}$ , is estimated by summing up the individual demand functions for forest land.

We separate the demand  $D_{FL}$  for and supply  $S_{FL}$  of land into two distinct decisions, even if those farmers who decide not to use the land for agriculture may be the same as those who decide to use it for forestry. Cropper et al. (1999) drew a similar distinction between the demand for and supply of cleared land. First, in a prefecture, the supply of land is limited by its total land area. Second, the supply of land used for forest management must depend on the profitability of the competing land use, agriculture, and hence on its output price,  $PA$ , and input prices, the wage  $w$ , capital cost  $r$  and material cost  $m$ . Following the same procedure as in the demand function, we also include the variable  $R$  in the supply function. Therefore, the supply of aggregate forest land can be expressed as follows:

$$S_{FL} = S(w, r, m, R, PA, A). \quad (3)$$

Capital markets in rural China are poorly developed. Therefore, use of an interest rate variable for capital costs in Eqs. (2') and (3) is not possible. It is also difficult to find any reliable information on shadow costs of capital. Consequently, we do not try to identify or estimate the demand and supply functions for forest land separately. Rather, the reduced-form equation for the equilibrium level of forest land in a prefecture is estimated. The reduced-form equation for forest land allocation can be expressed as:

$$FL = F \left( \begin{matrix} PT, PA, w, m, R, DM, A \\ +, -, ?, ?, +, +, 1 \end{matrix} \right). \quad (4)$$

The expected signs of the effects on forest land allocation are indicated below each factor. The effects of the unit costs of labor and material

cannot be determined a priori, because the series used reflect unit prices for total rural labor and material costs in a prefecture, i.e. they include both the forestry and agriculture uses of the inputs. Both the liberalized access to timber markets and a higher proportion of HRS ownership are expected to increase the land area under forests. We make the further assumption that,  $A$ , the total land area in a prefecture has a unitary effect on the amount of land allocated to forests.

### 3.2. A household-production harvesting model

Next, we justify the timber supply model used. Using the profit maximization problem described by Eq. (1) and applying Hotelling's lemma, the derivative of the profit function with respect to timber output yields the timber supply function. According to this function, timber supply depends only on timber price, the input prices and the timber market access factor.

However, (short-term) harvesting decisions depend on the volume of current forest resources. Furthermore, because of poorly developed capital markets, which are typical for a developing country, and possibly also because of valued non-timber outputs of forests, timber production decisions may depend on owner's preferences. These features cannot be adequately described using the above static (long-run equilibrium) profit maximization model. Instead, a household production model, based on utility maximization, offers a suitable tool for studying timber harvesting decisions.<sup>3</sup> A household production model augmented with biomass harvesting predicts that timber harvesting decisions depend on consumption needs, if borrowing and lending are restricted and/or if non-timber outputs are also valued (see, e.g. Binkley, 1987; Max and Lehman, 1988; Koskela, 1989). The implication for an estimable timber supply (harvest) function is that timber supply depends not only on prices and costs in forestry and the volume of merchantable timber but also

<sup>3</sup>See Singh et al. (1986) for applications of household production models in studying the agricultural sector in developing countries.

on, e.g. the non-forestry incomes of the farmers, other preferences related to owner-specific factors and expectations.

When harvesting decisions depend on the farmers' consumption needs, the household production model gives an ambiguous sign for the timber price effect. The (intertemporal) substitution effect (e.g. that farmers start selling more timber as a result of a timber price increase) is positive but the income effect due to decreasing marginal utility of income is negative.<sup>4</sup> Furthermore, the predicted sign for non-forestry income is negative, owing to the liquidity constraint, i.e. as non-forestry income increases, less harvested timber is required at a given level of consumption. For formal derivation of the comparative static signs, the reader is referred to, e.g. Max and Lehman (1988) or Kuuluvainen et al. (1996). The behavioral equation for timber harvesting of a representative farmer in a particular prefecture in China, can now be written as follows:

$$H = H \left( S_{-1}, R, PT, PA, w, m, DM \right) \quad (5)$$

$\begin{matrix} + & & & - & & & + \\ & ? & & & ? & & \end{matrix}$

In Eq. (5),  $H$  is the harvest in  $\text{m}^3/\text{ha}/\text{year}$  and  $S_{-1}$  is the stock of forest in  $\text{m}^3/\text{ha}$  with a 1-year lag. If the timber stock has no in situ value to the owners, the household production model with biomass harvesting predicts that the effect of the stock on the harvest will be unity (Kuuluvainen et al., 1996). This has often been assumed to be the case in aggregate timber supply estimations using time series data in which it is difficult to estimate the effect empirically (Binkley, 1987). Owing to data limitations agricultural price  $PA$  is used as a proxy for non-forestry income. Rural indexes for labor cost  $w$  and material cost  $m$  here describe the input costs in harvesting.<sup>5</sup> However, these

cost terms have a larger weight in agriculture, and may therefore affect the profitability of agriculture. The expected signs in the harvest equation are ambiguous.

Data on other owner-specific factors were not available at prefecture level. The experiments with lagged variables often used to model expectations and the short-term dynamics did not improve the statistical performance of the harvest equation. Therefore, these variables are neglected in estimation. Finally, we assume that de-collectivization,  $R$ , has a positive effect on the intensity of forest use. The effect of market liberalization, if statistically significant, can be assumed to be positive.

#### 4. Data

The data were obtained by combining the data collected by Yin and Newman in 1992 covering the period 1978–1989 with the data collected in this study in 1998 covering the period 1989–1995. The panel data set consists of 10 prefectures in two provinces in the south (Fujian and Jiangxi) and two in the north (Henan and Anhui) (see Fig. 1) covering 18 years with 180 observations in all.

Data on forest land area and inventory (standing stock) are based on the national and provincial forest inventories and statistics obtained from the provincial and prefecture forest bureaus. In China, national forest inventories are usually conducted every five years. The four forest inventories were conducted in 1973–1976, 1977–1981, 1984–1988 and 1989–1993. These national forest inventories normally provide only provincial-level data. The provincial inventories, which have been conducted several times, provide data at county and prefecture levels. Prefectures usually have their own annual estimates for their forest resources based on inventory data and annual harvests and growth. In our study sample inventory information for some years with missing data had to be interpolated.

Annual timber harvesting, the procurement price and the timber sales price were collected from the local forest bureaus and timber trading companies. The agricultural commodity price, the

<sup>4</sup>Max and Lehman (1988) concluded that the total price effect is likely to be positive if the elasticity of marginal utility of income is equal to or less than one. Technically, the elasticity of marginal utility of income is equivalent to relative Arrow–Pratt risk aversion, which is usually believed to be approximately unity (e.g. Arrow, 1965).

<sup>5</sup>We assume the unit costs to be independent of the harvest rate.

average wage for farming and forestry and the rural industrial materials price indexes were collected from provincial statistical yearbooks. All prices used in this study are at provincial level since prefecture level prices are not available. The ratio of HRS land to total collective forestry land is based on Dong (1987), Xu (1987), Yin and Newman (1997), and national forestry inventories. The timber procurement price is used as a proxy for the timber producer price that farmers face in the south, whereas for the northern region the timber sales price is available (see Fig. 3). All output and input prices have been deflated using retail prices as the deflator.

### 5. Econometric specification and empirical results

We estimated the equations for forest land and timber harvest using the least squares dummy variable model (e.g. Greene, 1997). The estimable equations for forest land and annual harvest are specified as follows:

$$\begin{aligned}
 FL_{it} = & \alpha_1 + \sum_{j=1}^4 \beta_{1j} R_{jt} + \beta_2 RL_{jt} + \sum_{j=1}^4 \beta_{3j} PT_{jt} \\
 & + \beta_4 PA_{it} + \beta_5 w_{it} + \beta_6 m_{it} + \beta_7 DM_{it} \\
 & + \sum_{i=2}^{10} \beta_{8i} D_i + e_{it}, \quad (6)
 \end{aligned}$$

and

$$\begin{aligned}
 H_{it} = & \alpha_1 + \beta_0 S-1_{it} + \sum_{j=1}^4 \beta_{1j} R_{jt} + \beta_2 RL_{jt} \\
 & + \sum_{j=1}^4 \beta_{3j} PT_{jt} + \beta_4 PA_{it} + \beta_5 w_{it} + \beta_6 m_{it} \\
 & + \beta_7 DM_{it} + \sum_{i=2}^{10} \beta_{8i} D_i + e_{it}, \quad (7)
 \end{aligned}$$

where  $FL$  is the forest cover rate (% of total land).<sup>6</sup>  $H$  is the annual timber harvest (in  $m^3$  per unit of forest land area). The common intercept denoted by  $\alpha_1$  is also the intercept for Prefecture 1. Common slopes are denoted by  $\beta$ , and  $e_{it}$  is a normally distributed error term. The subscript  $t$  (from 1 to 18) refers to the years from 1978 to 1995; the subscript  $i$  (from 1 to 10) and  $j$  (from 1 to 4) index the ten prefectures and the four provinces (Fujian and Jiangxi in the south, Henan and Anhui in the north), respectively.  $PT$  and  $PA$  are the deflated timber price and the agricultural commodity price;  $w$  and  $m$  are the deflated provincial average wage rate in farming and forestry and the rural industrial material price, respectively. Capital costs could not be considered since the official interest rate does not reflect the capital costs perceived by rural farmers.  $R$  is the ratio of forestry land under the household responsibility system (HRS) to the total forestry land area and indicates the land tenure structure.

The land tenure change (see Fig. 2) leveled off around 1985, and the potential effects of the HRS might have been exhausted by the late 1980s. Therefore, we use a dummy variable ( $RL$ ) that allows for the different impact before and after 1986 and the cross effect of the HRS intensity level across provinces.  $RL$  is  $R \times D_{86}$ , where  $D_{86} = 0$  for the year before 1986; and  $D_{86} = 1$ , otherwise.  $DM$  is a dummy variable for the free-market access years (the years 1985 and 1986 and 1993–1995 for the south and all years for the north).

It is clear that geographic and demographic factors and socio-economic characteristics in prefectures affect the allocation of land between forestry and agriculture as well as harvest rates. These differences across regions may be significant but difficult to measure with the available statistical material. In order to avoid omitted variable bias in the slope coefficients, the unobservable factors can be taken into account using either cross section-specific constants or random terms. Because region-specific factors are known by the decision-makers in each prefecture and the number of cross section units is small, fixed effects rather than a random effects model

<sup>6</sup>The total land on the right-hand side would have perfect collinearity with the regional dummy. Therefore, we use forest land as percentage of total land as the dependent variable.

must be used (Hsiao, 1986, p. 41). In Eqs. (6) and (7)  $D_i$  is the dummy variable for the prefectures ( $i = 2, 3, \dots, 10$ ).<sup>7</sup> According to the  $F$ -test, a model with prefecture dummies could not be rejected when tested against models assuming: (1) no regional differences (pooled least squares); (2) differences between south and north only; and (3) provincial differences only.

Since the effects of the land tenure arrangements may vary across provinces because of differences in environment, administration and implementation of policies, we estimate individual slope coefficients for land tenure change for each province. We also allow for different coefficients for timber prices in each province.

The model was estimated using natural logarithms, except for  $R$ , which is a ratio between 0 and 1, and the dummy variables. Because of autocorrelation in both equations, an autocorrelation corrected lag structure was used (Greene, 1997, p.

639). The statistical performance of the models was not improved by introducing the lagged values of the independent variables except for lagged inventory in the harvesting equation. Estimations were made using LIMDEP (Version 7).

Estimated results in Table 1 show that the land tenure reform promotes the expansion of forest land since the HRS has a significantly positive effect on forest area in the Henan and Anhui provinces. For the Fujian and Jiangxi provinces, the effect is not statistically significant. Furthermore, the  $RL$  that captures the difference between the transition period 1978–1986 and the stable HRS period 1987–1995 and the difference in de-collectivization between provinces since 1986 receives a statistically significant positive coefficient. The result does not support the widely held view that free market access causes loss of forest land. Over-harvesting may be observed during the early periods of market freedom, but according to our results market freedom itself does not promote excessive harvesting. The effect of the free market dummy,  $DM$ , was clearly not statistically significant either for land allocation or harvest, and the coefficient was close to zero in absolute terms. The effect of free market access

<sup>7</sup>This is equivalent to estimating the least squares dummy variable model with 10 individual effects and no common intercept. When we use a common intercept, however, the estimated dummy variables  $D_i = \alpha_i - \alpha_1$  are more informative as we are interested in regional differences.

Table 1  
Coefficient estimation<sup>a</sup>

Variables	Descriptions	Forest cover rate (%)	Harvest (m <sup>3</sup> /ha/year)
$\alpha$	Common intercept	1.41 (1.52)	3.23 (1.25)
$S_{-1it}$	Inventory with a 1-year lag		0.88 (5.51)
$R_{1t}$	HRS ratio in Fujian	-0.34 (0.66)	2.29 (2.83)
$R_{2t}$	HRS ratio in Jiangxi	-0.19 (1.29)	0.24 (1.05)
$R_{3t}$	HRS ratio in Henan	0.71 (6.79)	-0.02 (0.15)
$R_{4t}$	HRS ratio in Anhui	1.13 (8.93)	1.04 (5.16)
$RL_{it} (D^*_{86} R_{it})$	D86 (= 1) for year after 1986	0.30 (7.14)	0.14 (2.10)
$PT_{1t}$	Timber price in Fujian	0.05 (0.68)	-0.10 (0.82)
$PT_{2t}$	Timber price in Jiangxi	-0.10 (1.23)	-0.33 (2.68)
$PT_{3t}$	Timber price in Henan	-0.37 (3.47)	-0.16 (0.94)
$PT_{4t}$	Timber price in Anhui	0.03 (0.33)	-0.34 (2.40)
$PA_{it}$	Agri. goods price	-0.28 (2.23)	-0.37 (1.90)
$w_{it}$	Wage in farming and forestry	0.32 (2.42)	0.25 (1.21)
$m_{it}$	Rural industrial product price	0.37 (1.77)	-0.86 (2.42)
d.f.	Degrees of freedom	148	147
a.c.	Autocorrelation	0.42	0.37
$R^2$	$R$ -squared	0.99	0.98

<sup>a</sup>Notes: (1) The  $DM$  variable (free market access) was dropped in this regression after found that it was not significant. (2) Numbers in parentheses are  $t$ -values. (3) The nine dummy coefficients are excluded.

is already captured by prices and costs, which embody changes both in market access and demand and supply. To improve the performance of the regressions, the free market dummy, *DM*, was dropped in the final estimation.

The results also imply that the forest land area increases as the agricultural commodity price decreases or labor and material costs increase indicating that land allocation may in fact be affected by expected profitability of land use in agriculture relative to forestry. Because agriculture is more labor and material-intensive than forest management, rising labor and material costs are more advantageous for forest management. Recent national forest inventories (1984–1988 and 1989–1993) based on the same sites indicated substantial shift from agricultural land to forest land. Timber prices seem to have negative effects on land allocation to forestry. However, the coefficients are not statistically significant, except for Henan.<sup>8</sup> This may be due to the short observation period, which is not able to fully describe the long-run equilibrium relationship between timber prices and land allocation predicted by the theoretical reduced-form equation. However, market distortions caused by arbitrary taxes and fees imposed on forestry by provincial and prefecture-level governments meant that prices were historically a poor indicator of the future developments in timber market.<sup>9</sup> Zhang et al. (1999), among others, support the view that the timber price taken by farmers differs greatly from the market price. In addition, the heavy bureaucracy associated with the harvesting procedure may prevent farmers making harvesting decisions freely, even in a free timber market. Therefore, the long-run

relationship between timber prices and land allocation in this study remains a somewhat open question.

According to the estimated results of the timber supply equation, de-collectivization has a positive effect on the harvest intensity, as measured by statistically significant impacts in Fujian and Anhui, and between provinces, as measured by *RL*. Agricultural goods prices have a negative effect on timber harvest. This can be interpreted through the simultaneity of consumption and harvest, which causes farmers to have forestry income targets. An increase in agricultural income means that less timber harvest is required for the same level of consumption. Simultaneity of harvest and consumption may also be indicated by the negative coefficient of the timber price, which can be interpreted through the dominating income effect in the Jiangxi and Anhui provinces (see footnote 4). Price effects are not statistically significant in Fujian and Henan. Fujian is much more prosperous than Jiangxi province in the south, and Henan depends less on forest income than the Anhui province (particularly in the prefectures we examined) in the North. Therefore, the intertemporal positive substitution effect of timber prices can be expected to be stronger in these provinces than in Jiangxi and Anhui, causing a non-significant total effect. However, the reservations concerning prices as market signals to farmers described above, are also relevant when the elasticities of harvest with respect to timber prices are considered. Finally, we note that the elasticity of harvest with respect to the (lagged) inventory level is close to unity, as predicted by the theoretical biomass harvesting model without valued non-timber outputs.

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<sup>8</sup>We also estimated the model using total harvest. The results remained qualitatively the same, except that all the price effects were non-significant. This may be due to heteroscedasticity. However, it is also possible that rising prices encourage harvesting on poorer sites, thereby reducing per hectare harvests.

<sup>9</sup>The long-run economic relationships are often studied empirically using cross-section data under the assumption that economic units on average have adjusted to the long-run equilibrium. Unfortunately, with the 10 cross-section units of the present study this is not possible.

## 6. Conclusions

The results presented in this paper are consistent with the conclusion by Yin and Newman (1997) that policy impacts between the south and the north have been different. More importantly, the present study shows that there also is regional variation within the south and the north as indicated by the differing effects of de-collectivization

and prices for provinces in the south and the north. The results suggest that local-level institutional factors and economic conditions may play a role in land allocation between forestry and agriculture and also in the intensity of harvest. Generally, land tenure de-collectivization seems to promote forest land expansion. However, this instrument may require a supporting administrative system not present in all provinces studied, as the effect of de-collectivization clearly also differed between provinces in the south and the north.

The effect of timber prices on land allocation to forestry remains to a certain extent an open question owing to the unduly short observation period and the small number of cross-section units. The effect of prices on harvest rates in Jiangxi and Anhui was negative and statistically significant. This was interpreted to indicate that farmers may have income restrictions when making harvesting decisions, because consumption and production decisions are made simultaneously. If this is the case, it should be taken into account when implementing forestry extension and subsidy programs aimed at more efficient allocation of land between different uses and more efficient use of forestry land. For example, subsidy programs intended to promote harvesting and reforestation may have adverse effects for subsistence farmers.

However, the estimated price effects should be interpreted with caution. The market distortions caused by the arbitrary taxes and fees imposed on forestry by provincial and prefecture-level governments and the heavy bureaucracy associated with harvesting may make prices a poor indicator of market developments for farmers. The negative price effects may also partly be due to the fact that harvesting moves to poorer sites when prices increase, thereby reducing per hectare harvests. Improving the market mechanism, providing more transparent market information for rural farmers, e.g. introducing the systematic collection of a site productivity tax could improve the predictability of land owner behavior to market incentives and policies (Zhang and Liu, 1999). Liberalization of timber markets does not seem to be a critical issue at present, but regional barriers and fees imposed on timber trade that could not be stud-

ied with our data may cause distortions, which should be analyzed further.

### Acknowledgements

The authors wish to thank Runsheng Yin and David Newman for providing part of the data and Professor William Hyde's comments. Advice and assistance in data collection by Prof. Zai Zhongqi of Beijing Forestry University and Mr Xu Wenxin and Mr Chen Qihua of Fujian College of Forestry, and comments by two anonymous referees are also greatly appreciated. This work was carried out with the aid of a grant from the International Development Research Centre's (IDRC) Economy and Environment Program for Southeast Asia (EEPSEA).

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