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Markets, Government Policy, and China's Timber Supply

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China's domestic demand and exports of wood products are rising rapidly compared to domestic supply. The determinants of timber supply in China were investigated with panel data from 25 provinces from 1999 to 2009. The results indicated that China's timber supply had responded to both market forces, reflected by timber prices largely determined by world demand and supply, and to government policies expressed by production quotas and the tenure reform on collective forestland. The price elasticity of China's timber supply was estimated at 0.31 ± 0.12. The inelastic response of production to the quota (0.20 ± 0.02) suggested that government had a limited, though significant, control of timber supply. Other things being equal, the land tenure reform increased timber supply by 18 ± 8 percent, where and when it had been implemented.

1   Introduction

China's domestic timber supply is limited, due in part to a long history of excessive harvesting, and the low quality and young age of existing forests. The forest area per capita, 0.2 ha, is well below the world average of 0.6 ha, and the average stock density of 71 m^3/ha is approximately half of the world average (FAO 2010). In addition, mature or near mature forests account for only 27% of the total forest area (SFA 2010).

In contrast with this limited resource, China's wood demand has increased rapidly, driven by its strong economic growth, averaging 11% per year from 2005 to 2009 (IMF 2010), and its growing share of world exports which reached 13% for wood-based panels in 2009 (FAO 2012), and 16% for wood furniture (UN 2011). Consequently, China depends heavily on foreign supply. In 2009 it imported 26% of its industrial roundwood consumption, estimated at 126 million m^3 in 2009 (FAO 2012).

Meanwhile, growing environmental concerns have led to a change in China's forest policy, from encouraging industrial harvesting to protecting and restoring ecological systems. This change exacerbates the shortage of domestic wood supply. Yet, information on the functioning of the Chinese roundwood market is scarce. Especially lacking are quantitative studies suitable for forecasting and policy analysis.

China's timber supply is influenced by markets and by the government. A free market mechanism for timber was introduced in the mid-1980s. However, initially a dual system of compulsory delivery and free market coexisted. From 1993 to 1998, the market liberalization accelerated. To date, all price controls have been lifted and free competition has been established in collective forest areas. In state-owned forests, except special reserves, 90% of the timber harvest appears to be sold in free markets (Zhang et al. 1999).

As policies continue to evolve, and with the participation in the Asia Pacific Economic Cooperation and accession to the World Trade Organization, China's forestry has become increasingly influenced by world markets and policies. Import tariffs on logs, sawnwood, wastepaper and pulp have been eliminated since 1999. Furniture tariffs, 78% in 1992, were reduced to zero in 2005. Wood-based panels tariffs were reduced to 1%–10% in 2010 and those on paper and paperboard to 2%–7.5% (Government Customs 2012).

Nevertheless, the Government has maintained some control on timber supply. China's Forest Law specifies that annual harvests should not exceed the nationwide forest increment. Accordingly, a production quota applies to all forests irrespective of ownership since 1985. China's State Forestry Administration (SFA 2012a) sets the yearly quotas based on the statistics of the National Forest Resource Inventory. Then the quota is divided and distributed to local governments. Ultimately, logging licenses are issued to ensure that, at least in principle if not in fact, timber production does not exceed the quota. According to regulations, a firm or an individual is required to submit an application form, the forest property right certificate, and other documents to the township forestry station. The final approval is made by the county forestry bureau according to its annual logging quota (Li 2007). However, the procedures lack transparency, and an objective of this study was to determine the effectiveness of these quotas in determining supply, apart from the potential effect of prices.

The National Forest Protection Program (NFPP), implemented after the 1998 flash floods of the Yangtze and other waterways in the South and Northeast, has also affected the timber supply. In seventeen provinces logging was banned or restricted on natural forests, as distinct from plantations. During the first stage of the NFPP (1998–2010), the annual harvest was reduced by 21 million m^3, or approximately 7% of the total roundwood harvest in 2009 (FAO 2011). The second stage, from 2011 to 2020, is meant to strengthen the logging ban, extending it to eleven more counties (SFA 2012b).

Another potentially important new policy is the tenure reform on collective forests. China's forestland is owned by the state or by village collectives. According to the seventh National Forest Resource Inventory (2004–2008), 60% of China's forests are collectively owned, and their importance as timber providers has grown since 1997. According to Miao and West (2004) 46% of the domestic production comes from collective forests.

The collective forestland tenure has changed

several times since the foundation of the People's Republic of China. However, it is still insecure and incomplete, such that neither the collective village nor households have incentives to manage collective forests (Su et al. 2008). To stimulate forest management, revitalize the forest sector and improve forest farmers' livelihood, the Chinese government launched a nationwide forest-land reform in 2003, designed to give individual farmers some secure and transferable rights to currently collective forest. Although the ownership of forestland doesn't change (in China, the tenure of trees and forestland can be distinct, while all lands are state or collectively owned, the trees can be owned by households (Demurger et al. 2009)), the reform gives farmers the right to use, lease or mortgage forests for seventy years (Xu et al. 2010).

The role of government quotas and the NFPP on China's timber supply has been recognized in the literature, e.g. Zhu et al. (2004). Yin and Xu (2010) find that timber harvests have increased in provinces with tenure reform on collective forestland. However, this may not be the sole determinant. The economic reforms begun in 1993 have made China's forest sector more and more competitive, presumably giving more importance to the role of prices and costs in timber supply. Yet, little is known quantitatively about this aspect of China's supply. Table 1 summarizes some of

the parameters that have been used in past studies. The price elasticity based on author's judgment varies from 0.2 to 0.6, implying an inelastic supply which may be plausible given the quota restrictions. The results based on Chinese data vary from about 0.5 to 1.4.

The objective of the present study was to investigate further the influence of markets and government policies in China's timber supply. Specifically, we tested the effect of prices and costs in addition to the quotas and the land tenure reform in the determination of timber supply. The next section of this paper describes the model and methods, based on panel data from 25 provinces observed from 1999 to 2009. This is followed by the results which suggest that both markets, through timber prices, and government policies through the quotas and the land tenure reform, have had significant effects on China's timber supply.

2 Methods and Data

2.1 Theoretical Model

The microeconomic theory of markets suggests the following general model of timber supply (Brännlund et al. 1985, Binkley 1987, Bolkesjø

Table 1. Previous estimates of elasticity of China's timber supply.

Source	Data	Method and observations	Elasticity of supply		
			Price	Stock	Area
Binkley and Dykstra (1987)		Authors' judgment	0.4		
Buongiorno et al. (2003)		Authors' judgment	0.2[a)], 0.6[b)]	0.2[a)], 0.4[b)]	
Liu (2005)	Government reports from four counties in three provinces from 1978 to 2004	OLS, 108	0.46**		
Yan and Jiang (2008)	Household surveys in Fujian province in 2000, 2003 and 2005	FGLS, 172	1.36***		0.98***
Yin and Xu (2010)[c)]	Household surveys in five provinces in 2000 and 2005	Treatment effect, 3612	0.86		0.003

[a, b)] The price elasticity of sawlogs and pulpwood supply respectively.
[c)] The regression model in this paper is linear, without logarithmic transformation of the variables, so the parameters are not elasticities.
*** Significant at the 0.01 probability level; ** Significant at the 0.05 probability level.

et al. 2010), to represent the aggregate production (i.e. harvest) in a large area:

$$Q = f(P, W, I, R, Z) \tag{1}$$

where f is a functional form that relates timber production in a particular location and time period, Q, to the timber price, P, the cost of input in timber harvesting, W, the level of growing stock, I, the interest rate, R, and other factors that may influence timber supply, Z.

This study dealt with China's provinces, i, observed over a number of years, t, and Z referred to government policies expressed by the timber production quota including the reductions due to the Natural Forest Protection Program, and the Tenure Reform on Collective Forestland (TRCF). So that Eq. 1 became:

$$Q_{it} = f(P_{it}, W_{it}, I_{it}, R_{it}, QUOTA_{it}, TRCF_{it}) \tag{2}$$
$$\quad\quad (+)\ \ (-)\ \ (+)\ (?)\quad\quad (+)\quad\quad (?)$$

The signs in parentheses indicate the expected partial effect of each variable, other things being equal. The theory of the firm suggests that a higher timber price stimulates production, while higher costs depress it. The higher the inventory level, the higher the growth and the lower the harvest cost, which implies a positive effect on timber production. Some literature suggests a positive effect of the interest rate on supply because a higher interest rate increases the opportunity cost of holding trees (Duerr 1960, Binkley 1987, Amacher et al. 2009, Bolkesjø et al. 2010). However, Farzin (1984) and Hannesson (1987) argue that although a lower discount rate may have such a "conservation effect", it also has an "investment effect" by lowering the cost of investment in production capital, such as harvesting machinery, which makes the expected effect of discount rate on timber production ambiguous.

Inasmuch as the government policies were effective, tighter production quotas including the logging ban or restrictions of the NFPP should have decreased production where and when they were applied. Concerning the land tenure reform on collective forest lands, its main goal was to improve individuals' incentives to manage forests. It is unclear how this reform has influenced

timber supply, other things being equal. While Yin and Xu (2010) find that timber harvests have increased in provinces with reform, Xie et al. (2011) suggest, based on household survey data, that this effect is not statistically significant.

2.2 Econometric Methods

The empirical form of the model corresponding to Eq. 2 was:

$$\ln Q_{it} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln W_{it} + \beta_3 \ln I_{it}$$
$$\quad + \beta_4 \ln QUOTA_{it} + \beta_5 R_{it} + \beta_6 TRCF_{it} + u_{it} \tag{3}$$

with $u_{it} = a_i + \varepsilon_{it}$ \hfill (4)

where ln indicated the natural logarithm of a variable, so that β_1 to β_4 were the partial elasticities of production with respect to price, input cost, growing stock, and government quota, and β_5 was the semi-elasticity with respect to the interest rate, i.e. the percentage change in Q when R is increased by one unit (Wooldridge 2006, p. 720). *TRCF* was a dummy variable, taking the value 1 in the province and year that the tenure reform was implemented, 0 otherwise. Thus, β_6 measured the relative change of production due to the tenure reform on collective forests, all other variables being held constant.

According to Eq. 4 the error term, u_{it}, was composed of a province-specific effect, a_i, and of a residual disturbance, ε_{it}. Different assumptions regarding u_{it} led to three methods of estimation (Wooldridge 2006, p. 486).

(1) *Least squares with dummy variables* (LSDV) assumed that a_i differed by province and was constant over time. Each a_i was treated as a fixed parameter and represented the province-specific effects. LSDV was done by adding one dummy variable per province to Eq. 3. While this produced the same β coefficients as fixed-effects by time demeaning, it also gave direct estimates of the provincial effects. Although LSDV was unbiased, even if the a_i's were correlated with the explanatory variables, its drawback was that it used mostly the temporal variations within provinces. Thus, if the within variation of a variable was small, the effect of that variable could not be captured, even if it had an important effect on production.

(2) *Random effects-GLS* estimation assumed that the province effects a_i were random and uncorrelated with observed covariates. Then model (3) had a compound disturbance u_{it} with the usual properties, and generalized least squares (GLS) was used to eliminate serial correlation in the errors (Wooldridge 2006, p. 494). This approach made good use of both the cross-provinces and the time-series variation of the data. However, consistency of this estimator required that the explanatory variables be independent of the province effects, a proposition that was tested with Hausman's statistic (Wooldridge 2002, p. 486).

(3) *Instrumental variables.* Approach (1) and (2) assumed that the explanatory variables, especially prices, were exogenous. This was justified by the fact that no province has enough size to set prices. Guangxi, the largest producer in 2009, accounted for only 13% of national timber output. And, after the NFPP, the logging reduction in the northeast didn't influence timber prices much in other regions, contrary to what had been expected. Sun and Xu (2005) argue that this was because the reduction was substituted by timber imports. Indeed, China's entry in competitive international markets in the early 1990's made it to some extent a price taker. Nevertheless, as indicated below in the data section, there was substantial price variation between provinces, suggesting market heterogeneity and thus the possibility of endogenous prices within provinces. Therefore, the same models were re-estimated by two stage least squares/ instrumental variables. In the first stage, the price was predicted from the exogenous variables and the lagged price and production were used as additional instruments.

After estimating the timber supply equation, consistent predictions of production were obtained from the predicted logarithm of production with Wooldridge's method (Wooldridge 2006, p. 220).

2.3 Data

The data consisted of a panel of yearly data for 25 provinces of China (Fig. 1). Together, these 25 provinces accounted for 99% of China's production. The observations in each province were from 1999 to 2009. While some government control of

harvests persisted during that period, free markets became more pervasive. In 1998, all price controls were lifted and free competition was established in collective forest areas. As indicated above, in state-owned forests, most of the timber harvest was sold in free markets. In addition, the timber import tariff was cancelled on January 1, 1999 (Tian et al. 2008).

The timber production data for industrial roundwood, in million m^3, were obtained from the China Forestry Statistical Yearbooks (SFA 2009b). Due to missing production data for some years in Beijing, Gansu, Guizhou and Jiangsu, there were 263 province-year observations. The same source provided the nominal prices, in RMB/m^3. However, there were no price data for 107 of the 263 province-year combinations. In those instances, the price was estimated with a regression of the nominal local price on the nominal import price in the provinces and years with local price data, with dummy variables to account for provincial differences. The import price was the unit value of imports of industrial roundwood in China, obtained from FAO (2012), in current US dollars per m^3, converted into Yuan with the current exchange rate (World Bank 2012). Fig. 2 shows how the prices predicted with this regression compared with the observed prices. The strong relationship between the domestic prices and the import price may be explained by the fact that China was a large importer of industrial roundwood throughout the period considered. Data from FAO (2012) indicate that China has imported over 20% of its consumption of industrial roundwood since 2002. The nominal prices were transformed to real prices at constant 1990 RMB by deflating the nominal prices with the provincial price index (Government Statistics 2012).

The average labor wages in state-owned forest farms, in RMB/person/year, were used as a proxy of input costs. Nominal wages came from China Forestry Statistical Yearbooks (SFA 2009b). Like prices, wages were deflated with the provincial price index. The forest stock, in million m^3, by year and province, was also obtained from SFA (2009b), where it has been reported at five year intervals from 1999 to 2009, in conjunction with the National Forest Resource Inventory. The yearly inventory data were interpolated from these periodic inventory data.
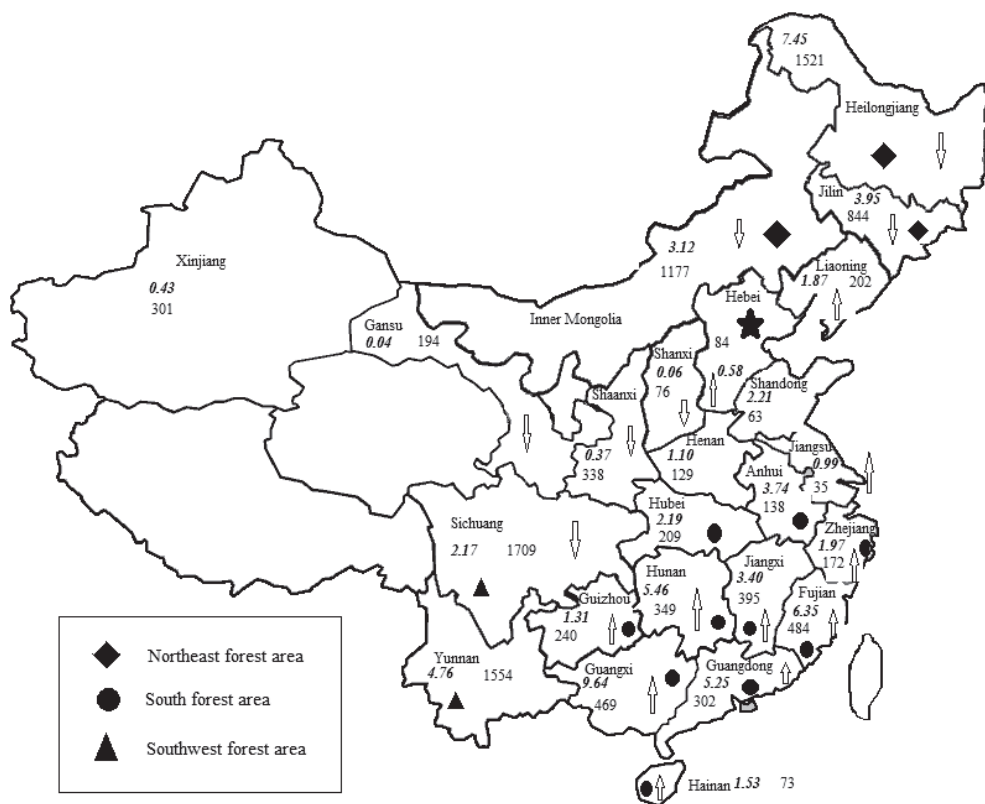
Fig. 1. Provinces of China used in the study. Bold italic numbers are timber production and regular numbers are forest stock in 2009, in million m^3. The arrows indicate provinces where production increased or decreased from 1990 to 2009. Beijing ($\star$), had a production of 0.075 million m^3 and a stock of 10.39 million m^3 in 2009.

The data on nominal interest rates, by province and year, came from Bank of China (2012). Like wages and timber prices the nominal interest rates were deflated by the provincial price index. The data on the production quota, in million m^3, by province and year were from the China Forestry Yearbooks (SFA 2009a). The government set the quota mostly according to the national forest inventory. Although the inventory was conducted continuously, it took five years for completion and publication. Thus, the quota changed little within each inventory cycle.

The provinces began the forestland tenure reform at different times. For example Fujian, Jiangxi, Jilin and Zhejiang, started the reform in 2003 and 2004, while Guangdong and Shandong took it up in 2008. The reform began with a pilot

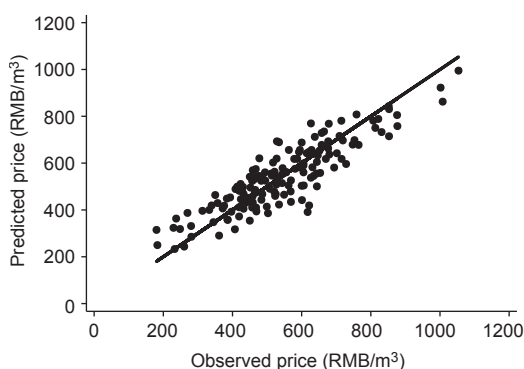

Fig. 2. Timber prices predicted with a regression of observed prices on import prices, plotted against observed prices, for the years and provinces of China for which prices were available. Points on the solid line indicate exact prediction.

implementation. About one year later it expanded to the entire province. The dummy variables referring to the reform were set to 1 when the reform became province wide and to 0 otherwise. The timing of the reform was obtained from SFA (2012a). By 2009 the privatization of forest lands had been achieved to varying degrees across the provinces (Table 2). For the provinces with less than 20% completion, the reform dummy variable was set to 0 for all years.

Table 3 shows the summary statistics of the data. There was much variation in all variables, a clear benefit of panel data. The last two col-

umns show that the within-province variation of timber production, timber price, wage rate, forest stock, and harvesting quota was smaller than between provinces, while the interest rate, and tenure reform varied more within provinces than between them. Production was less than the quota in 168 of the 263 usable observations by province and year, and the difference between quota and actual production tended to be larger in provinces with higher production.

The correlations between the variables in model (3) show that production was correlated mostly with the quota and the stock (Table 4). There was

Table 2. Degree of completion of the privatization of forest property in China in 2009.

Province	Percent	Province	Percent	Province	Percent
Fujian	98	Zhejiang	85	Hainan	22
Hubei	98	Hunan	85	Shanxi	15
Guizhou	97	Heilongjiang	82	Shandong	15
Sichuan	97	Henan	80	Gansu	14
Jiangxi	93	Jiangsu	60	Guangdong	12
Liaoning	91	Jilin	47	Xinjiang	5
Yunnan	87	Shaanxi	35	Beijing	0
Anhui	86	Neimenggu	35		
Hebei	86	Guangxi	34	National	63

Source: SFA (2012c).

Table 3. Summary statistics for observations in 25 provinces of China, from 1999 to 2009.

Variable	Mean	Min	Max	Standard deviation		
				Overall	Between provinces	Within provinces
Timber production (10^6 m^3)	2.20	0.004	9.43	2.13	2.03	0.76
Timber price (RMB/m^3)	235.8	34.2	467.4	81.4	71.4	41.4
Wage rate (RMB/person/yr)	4981.0	1337.2	33262.9	3909.1	3314.8	2166.6
Real interest rate (%)	0.18	−20.98	19.59	5.52	1.91	5.20
Forest stock (10^6 m^3)	394.67	6.86	1709.04	466.66	473.83	38.08
Quota (10^6 m^3)	2.72	0.0001	13.14	2.96	2.55	1.57
Tenure reform (0–1)	0.2	0	1	0.40	0.17	0.36

Table 4. Correlation between variables in regression models of timber supply.

	lnproduction	lnprice	lnwage	lnquota	lnstock	reform	interest
lnproduction	1.00						
lnprice	0.11	1.00					
lnwage	−0.11	0.27	1.00				
lnquota	0.78	−0.03	−0.03	1.00			
lnstock	0.49	−0.13	−0.25	0.19	1.00		
reform	0.27	0.22	0.33	0.28	0.15	1.00	
interest	0.05	0.18	0.25	0.07	−0.10	0.11	1.00

little correlation among the explanatory variables; the highest (0.33) was between wages and the reform.

3   Results

Table 5 shows the results of estimation of the timber supply with the LSDV and the random effects-GLS methods. In both cases, the supply was positively related to price, as expected from

theory if China had active timber markets. The price effect was statistically significant at least at the 0.01 level. The timber supply was inelastic, between 0.30 and 0.40 depending on the method.

Wages had the negative effect on supply that one would expect in a market setting where producers try to minimize cost of production, but the elasticity was not statistically significant at the 0.10 level, and less than 0.20 in absolute value. This result was unlikely to be due to collinearity of wages and prices, given their low partial correlation (Table 4), and the small standard error of the price variable.

Table 5. Timber supply equation for China estimated by LSDV and random effects methods.

	LSDV		Random effects GLS	
	Coef.	S.E.	Coef.	S.E.
lnprice	0.31	0.12***	0.38	0.12***
lnwage	−0.07	0.12	−0.17	0.11
lnquota	0.20	0.02***	0.24	0.02***
lnstock	0.31	0.17*	0.47	0.08***
reform	0.18	0.08**	0.17	0.09*
interest	−0.00	0.00	−0.00	0.00
Constant	0.95[a]		−3.04	1.21***
N	263		263	
df	232		256	
R^2	0.93		0.70	
Hausman Chi^2			42.5	***

Notes: The dependent variable is the natural logarithm of production. ln indicates the natural logarithm. The constant in LSDV is the average of the province effects. *** indicates statistical significance at the 0.01 probability level, ** at the 0.05 level, and * the 0.10 level. The number of observations was less than 275 due to missing data. Superscript [a] refers to the average of the province dummy variable coefficients.

Table 6. Timber supply equation for China estimated by LSDV and random effects, with 2SLS/instrumental variables.

	LSDV+IV		Random effects GLS+IV	
	Coef.	S.E.	Coef.	S.E.
lnprice	0.32	0.17*	0.47	0.18***
lnwage	0.00	0.12	−0.13	0.11
lnquota	0.19	0.01***	0.22	0.02***
lnstock	0.29	0.16*	0.46	0.09***
reform	0.17	0.08**	0.15	0.09*
interest	−0.00	0.00	−0.00	0.00
Constant	−0.54[a]		−3.92	1.39***
N	254		254	
df	232		247	
R^2	0.93		0.70	

Notes: The dependent variable is the natural logarithm of production. ln indicates the natural logarithm. The constant in LSDV is the average of the province effects. *** indicates statistical significance at the 0.01 probability level, ** at the 0.05 level, and * the 0.10 level. The number of observations was less than 275 due to missing data and lagged variables used as instruments. Superscript [a] refers to the average of the province dummy variable coefficients.

According to both estimators, the interest rate had no effect on timber supply in China. This result, confirmed in further tests below, was not strikingly different from that in other countries where few studies found statistical significance and same sign for the effect of the interest rate on timber supply (see Table 7).

The stock level had the expected positive effect, statistically and economically significant with both estimators, with elasticity ranging from 0.30 to 0.50 depending on the method. The quota had also a positive effect on the harvest, with elasticity between 0.20 and 0.25. Thus, although the quota did significantly affect production it controlled less than a fourth of its change. The reform meant to give ownership of the forests to local communities had a positive and statistically significant effect on production. Where and when the reform was applied timber production increased by approximately 18 percent.

The goodness of fit measured by R^2 was substantially higher with the LSDV estimator than with random effects, even after adjustment for the degrees of freedom lost due to the 24 dummy variables used in LSDV. Fig. 3 shows the predicted and observed production in all provinces and years according to the two methods. The spread around the 45 degrees line shows clearly the better overall fit of the LSDV model, it also indicates that the random effects estimator tended to systematically underestimate production above about 5 million m^3. In addition, the Hausman test (Table 5) rejected the hypothesis that the parameters of the random effects and LSDV estimator were the same. This suggested that the residuals of the random effect model were correlated with the explanatory variables, so that the random effect model was inconsistent.

Table 6 shows the results of re-estimating the models by two-stage least squares to take into account the possibility of endogenous prices. The lagged price and production were used as instruments in addition to the exogenous variables. Given the standard errors, the results were quite similar to those obtained by assuming exogenous prices. The goodness of fit, after allowing for the loss of degrees of freedom due to the lagged instruments, was nearly the same as in Table 5. The price elasticity was slightly higher with the endogenous prices assumption. The wage elastic-
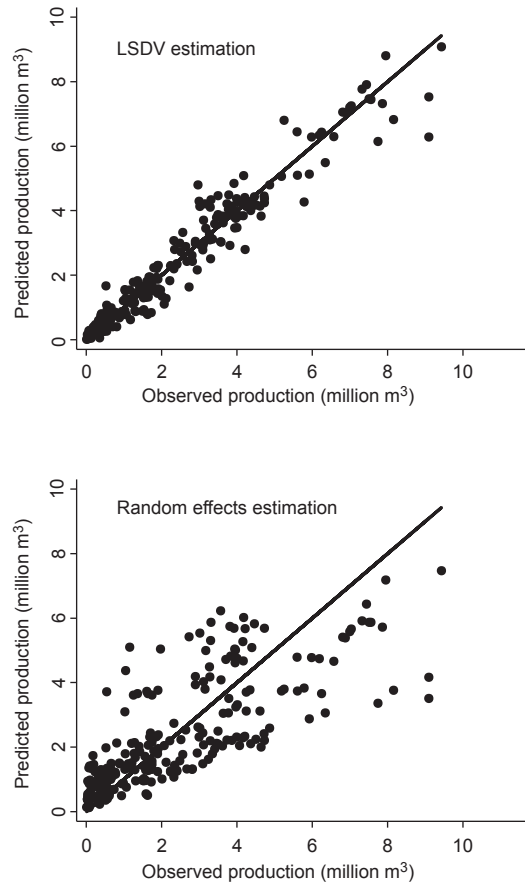

Fig. 3. Observed and predicted production in 25 provinces of China from 1999 to 2009, with the LSDV and random effects estimation. Points on the solid line indicate perfect prediction.

ity was still not statistically significant at the 0.1 level. The effects of the quota, reform and stock were practically the same as in Table 5, with either LSDV or random effects. Fig. 4 shows the observed and predicted production obtained with the simpler LSDV model assuming exogenous prices, by province and from 1999 to 2009. The predictions with LSDV and instrument variables to account for endogenous prices were nearly identical. The model appears to fit well the spatial as well as the temporal pattern of production. The main errors were in the province of Guangxi, where production increased more than predicted in the last three years of observation.

Table 7. Examples of wood supply parameters from studies outside of China.

Country	Authors	Data	Method	Production data	Elasticity		Cutting cost	Interest rate
					Price	Stock		
Finland	Hetemäki and Kuuluvainen (1992)	1960–1988	2SLS	Summation of nonindustrial private forest owners	0.81[c] (1.86)	4.66[c] (4.30)		
Finland	Toppinen and Kuuluvainen (1997)	1960–1992	2SLS	Summation of nonindustrial private forest owners	0.16[b] (0.39) 0.41[c] (2.06)			−1.99[b] (−2.39) −0.49[c] (−0.78)
Norway	Bolkesjø and Solberg (2003)	1989–1997	Fixed effects Tobit	14 468 nonindustrial private forest owners	0.40[a]***			0.28[a] ***
Norway	Bolkesjø et al. (2010)	1980–2000	First differencing	102 municipalities	0.91[b] ** 0.53[c] **	2.04[b,c] **		0.30[b,c]
Sweden	Brännlund et al. (1985)	1953–1981	2SLS[b] OLS[c]	Country level data	0.61[b] * 0.74[c] **		−0.85[b] ** −0.09[c]	
Sweden	Hultkrantz and Aronsson (1989)	1961–1984	2SLS	Summation of nonindustrial private forest owners	0.68[a] *	0.23[a] *	−1.00[a] **	−1.17[a]*
USA	Adams and Haynes (1980)		2SLS	Seven regions	0.16 to 0.99[a]	0.20 to 1.00[a]		
USA	Newman (1987)	1950–1980	3SLS	Softwood market in south	0.55[b] ** 0.23[c] *	0.39[b] ** 1.20[c] **		
Multiple	Turner et al. (2006)	1990–2000	2SLS	Industrial roundwood	1.31***	1.10**		

a, b, c) = roundwood, sawlogs, pulpwood; ***, **, * = significant at the 1%, 5%, 10%; t-statistics in parentheses.

4 Summary and Discussion

The objective of this study was to determine the role of markets and government policies in China's timber supply. The data related to 25 provinces from 1999 to 2009, on production, prices, wages, growing stock, and government actions. The fact that production was quite different between provinces gave power to the use panel data. It was this large variation that allowed measuring the partial effect of each variable. There might be differences in the supply equations across provinces, but we sought a description of supply for the entire country rather than a particular province. Thus, pooling the data across provinces seemed legitimate in this context. Nevertheless, Fig. 4 indicates that this general model gave also a good description of supply within each province.

The coefficients of all the variables were similar with LSDV or GLS-random effects estimation, and with or without the endogenous price

assumption. Nevertheless, the goodness of fit and Hausman criteria indicated that the LSDV estimator was preferable. The results suggest that market forces did influence China's timber supply. As expected in an economy with active markets, prices had a positive effect on supply. The price elasticity was 0.31 ± 0.12, statistically significant at the 1 percent level. This inelastic supply is similar to the values for China assumed by Binkley and Dykstra (1987) and Buongiorno et al. (2003), and estimated by Liu (2005), but it is smaller than the estimates of Yan and Jiang (2008) and Yin and Xu (2010).

Measured by the elasticity, the price effect was as important a determinant of supply as the growing stock (elasticity = 0.31 ± 0.17). Although the elasticity of supply with respect to wages obtained by LSDV was negative, as expected from theory, it was small and not statistically significant. Also, there was no relationship between timber supply and the interest rate. A possible explanation is that the "conservation" and "invest-
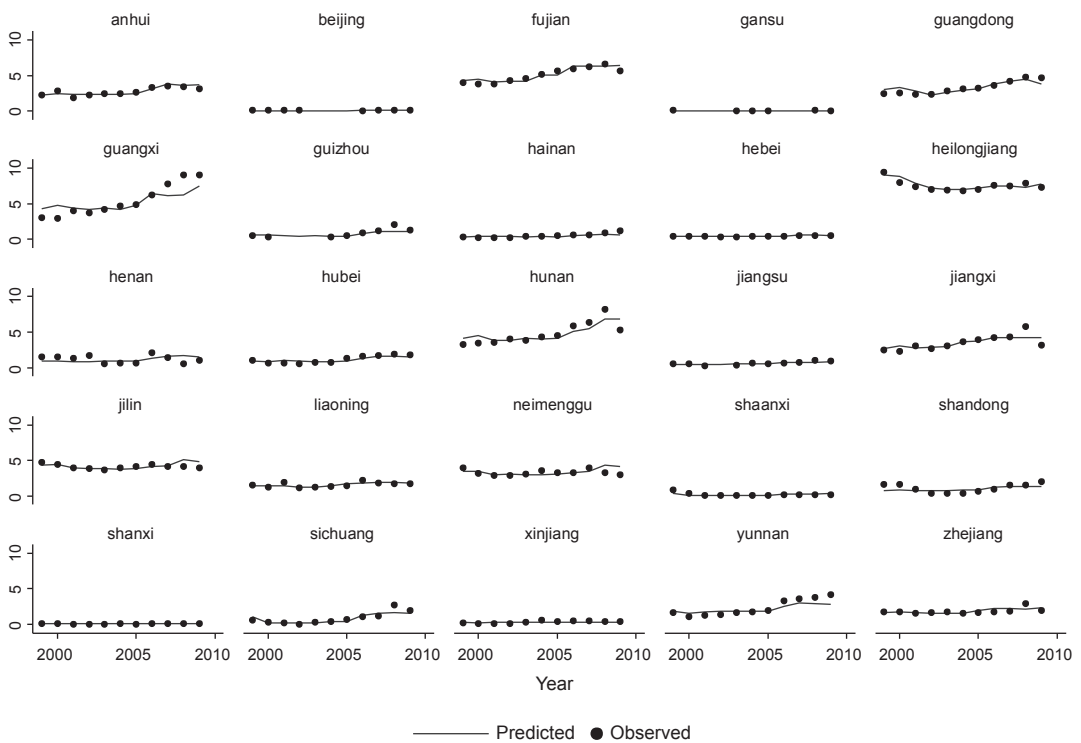

Fig. 4. LSDV predicted and observed production from 1999 to 2009, by province, in million m³.

ment" effects suggested by Farzin (1984) offset each other, although the result might also be due to imperfect capital markets. As indicated by the sample of studies in other countries summarized in Table 7, there is still much variation and uncertainty regarding the parameters of timber supply.

With regards to the government role on China's timber supply, the elasticity of production with respect to the continuing quota was both statistically and economically significant. However, its estimated value of 0.20 ± 0.02 suggests that government was far from having total control of supply. On its own, the land tenure reform appears to have increased timber supply by 18 percent where and when it was implemented. Given this effect, and the degree of completion of the reform in various provinces (Table 2), other things being equal the tenure reform would increase the national timber supply by 8.3 million m^3, or 11.5 percent compared to the level of production in 2009.

Thus, the tenure reform of collective forestland seems to have had the positive effect on supply that was eagerly expected (SFA 2012d) by a government wary of increasing internationally controversial log imports. Nevertheless, although after the tenure reform the trees belong to farmers, production is still restricted to some extent by the production quota. Accordingly, an associated reform of the timber production quota policy was started in 2009 and should be accomplished within five years to replace the harvesting quota by a record-keeping system (SFA 2012e). This is equivalent to relaxing the timber production quota, which should further increase China's timber supply according to the results obtained here. Working against these positive effects of the land tenure reform and quota relaxation will be the negative effects of the National Forest Protection Program, which will continue for at least a decade. The ultimate result of these conflicting policies and their combined effect with market forces on timber supply will depend in part on future prices, set largely by global markets. How China's forest sector will fit within these markets, and to what extent the land reform would mitigate the domestic timber deficit and curtail its imports, is examined in a related study (Zhang et al. 2012) with the Global Forest Products Model (Buongiorno et al. 2003), integrating the China's

timber supply reported here within the broader supply and demand of the world forest economy.

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