REFEREED ARTICLE

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Farm economics behind the evolution of Chinese rapeseed production

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ABSTRACT

In recent years Chinese rapeseed production has undergone significant changes. In order to explain this evolution, this article focuses on analyzing gross margin ratios and labour cost for rapeseed and wheat which is found to be the major competing crop from a grower's perspective. An econometric model applied to economic data from four main Chinese rapeseed producing provinces provides limited evidence that farm level economics play a role in grower's decision making: an increase in the gross margin ratio by 1% causes the share of rapeseed acreage in the subsequent year to go up by 0.09%; a 1% increase in the relative labour input leads to a reduction in rapeseed acreage by 0.45%. However, results also indicate that grower's decision making regarding cropping pattern is driven by other non-economic factors as well.

KEYWORDS: Rapeseed; China; cropping pattern; gross margin; labour input; log-log model

1. Introduction

Chinese agricultural markets have undergone significant changes in recent years. According to Lu (2002) especially the opening of markets in deficit regions as well as the decentralization of political responsibilities have to be mentioned. However, as reported by Gale (2009) there still significant policy intervention in place. This regards – among others – the so-called governors responsibility for grain production which means many governors have to make sure that grain production is in balance with provincial demand. Furthermore, local government authorities sometimes issue directives or subsidies to increase production of certain crops. Against this background the question arises to what degree farmers cropping decisions are driven by economic forces or by policy interventions.

As will be explained in greater detail below, Chinese rapeseed production has undergone some significant changes in recent years. Therefore rapeseed production seems to be an interesting case to analyze the relevance of economic incentives as driving forces of that change.

Rapeseed is a widely used, high economic value oil-bearing crop in China. It is the second largest oil-bearing crop in China (Statistical Yearbook 2008, p. 12–14). From the eighties of the last century, Chinese rapeseed production developed rapidly (Fu et al. 2003). Chinese rapeseed acreage and output ranked first in the world from 1985 onwards, it accounted for about 30% of the world's total rapeseed acreage and production (Wang, 2004). With more than 6 million hectares under rapeseed, the Yangtze River valley makes up about 85% of total Chinese rapeseed acreage (Qi et al. 2004). This region includes the provinces Hubei, Anhui, Jiangsu and Sichuan (see Figure 1). At the same time, these provinces happen to be the most developed regions in China.

There are two distinct cultivation methods in Chinese rapeseed production: 70% of the acreage is cultivated by transplanting small plants which have been pre-grown in small plots while only 30% of the acreage is direct seeded. In addition, harvesting is done predominantly by hand labour. By the end of 2007, only 6% of the whole rapeseed acreage was harvested by machines (Zong et al. 2008). Hence, calculations from Yang et al. (2003) indicate that about 60% of total cost in Chinese rapeseed production is labour cost. In China, rapeseed is produced as a spring crop as well as a winter crop. However, with a share of about 90% in acreage, winter rapeseed is by far the most important variant of the crop.

At the same time, China is a major global rapeseed producer as well as a major rapeseed consumer. Despite this importance of rapeseed, in recent years a significant reduction in acreage of this crop has occurred. Hence the question arises, what factors are driving this development and under what conditions the development can be reversed. Given the wide-spread assumption in Western Countries that politicians still have a strong impact on economic decisions in China the question arises, to what degree are farm level decisions driven by farm level economics. There is quite some literature available on the supply response of growers regarding price signals (Mohan, 1989; Gun, 1993; Edwin, 2008). In more applied approaches wheat supply in Pakistan is found to be significantly influenced by product prices (Khalid, 2003). Some literature on supply response also indicates that the response to price incentives is much weaker (Mythili, 2006). Some authors even suggest that non-price factors seem to dominate

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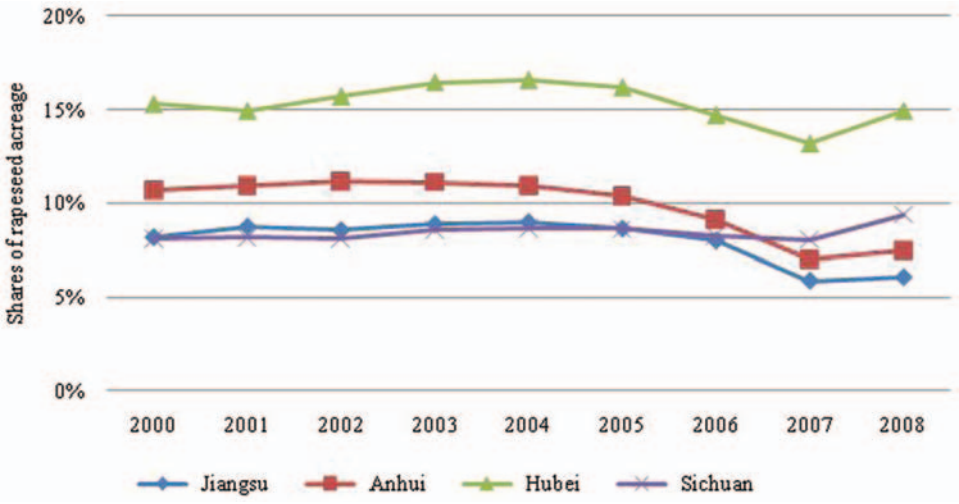

Figure 1: Shares of rapeseed acreage in four Chinese provinces
Sources: China Statistical Yearbook & own calculations

growers' decisions (Askari and Cummings, 1976; Gulati and Kelly, 1999).

This study attempts to use economic data in order to explain the change of rapeseed acreage over time. More specifically, it tries to explain these changes in land use patterns by analyzing gross margins and labour cost for rapeseed production and other major competing crops. Should gross margins for rapeseed production have been significantly and consistently lower than for other arable crops, the decrease of rapeseed acreage and production would be in line with economic theory.

With the lasting overall economic growth of China an increasing demand for labour has been created and the key sector of the economy which is able to provide such additional labour force is the agricultural sector. The booming industry outside agriculture is able to pay relatively high wages, which is why many former farmers decide to quit farming – at least temporarily. However, at the same time agriculture in most parts of China is still a very labour intensive industry. Hence, crops with a specifically high labour input will suffer from an increase in opportunity cost for family labour in particular.

Firstly, the major trends in rapeseed production in terms of acreage, yields per hectare and key production regions are described. Furthermore, statistical data as well as information about production systems applied in key rapeseed production regions are analyzed in order to identify crops which directly compete with rapeseed. Subsequently, the next chapter is devoted to data for gross margins realized in rapeseed and the competing crops as well as data about labour input and labour cost. Based on that, results of statistical and econometric calculations are presented in that part of the study and some key conclusions will be drawn. Finally, a summary of the paper is presented.

2. Evolution of rapeseed acreage and production in China

In China, rapeseed is one of the major crops together with rice, corn, wheat and soybean. At present, in addition to Beijing, Tianjin, Liaoning and Hainan, rapeseed is planted in 27 other provinces or regions.

Winter rapeseed areas include North China, Guanzhong the middle and lower parts of the Yangtze River region which mainly consists of the provinces Jiangsu, Anhui, Hubei and Sichuan. Furthermore, rapeseed is grown on the Yunnan-Guizhou Plateau and in the southern coastal areas. Spring rapeseed is mainly grown in China's western plateau comprising the provinces Qinghai, Inner Mongolia, Gansu and Xinjiang. Significant acreage in spring rapeseed can also be found in the northwest of China.

In 2008 there was a total acreage of 6.5 million ha in rapeseed. Out of this, the four most important provinces Hubei, Anhui, Jiangsu and Sichuan, which are all located in the Yangtze River Basin, accounted for around 50% of the entire Chinese rapeseed acreage. In order to be able to focus on the hot spots, the subsequent analysis will look at these four provinces. Their rapeseed acreage was in the range of 2.7 to 3.7 million ha from 2000 to 2008. In 2006 this acreage dropped off by 2.4% compared to 2005 and in 2007 another decrease of 6.2% occurred. However a modest increase occurred in 2008. Despite this significant reduction, the rapeseed acreage of these provinces always accounted for about half of total rapeseed acreage during the previous nine years (see Table 1).

As can be seen in Table 1, this continuity in the share of the key regions is caused by the fact that national cropping in rapeseed went down from 7,3 million ha in 2004 to 5,6 million ha in 2007 which means a decrease by about 23%. In 2008 rapeseed acreage grew by 16% although absolute figures were still significantly below 2000 to 2005 levels. Initially, the share of rapeseed acreage in each of the key provinces steadily increased from 2000 to 2004, but there was a decline after 2004, especially in 2006 and 2007. Due to an increase in rapeseed acreage in 2008 the share of this crop also went up again. Figure 1 shows the evolution of the individual trends of the provinces: In Hubei the share of rapeseed acreage in the total acreage is the highest of the four main producing provinces, reaching almost 17% in the peak season 2004. Although the share declined over the

Table 1: Rapeseed acreage of the four main provinces (1,000 ha)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Jiangsu	651	681	668	683	690	661	609	434	454
Anhui	965	953	1,002	1,015	1,003	954	836	620	670
Hubei	1,159	1,118	1,155	1,175	1,186	1,179	1,081	927	1,090
Sichuan	777	780	773	806	814	817	797	747	886
Sub-Total	3,551	3,532	3,599	3,678	3,694	3,610	3,323	2,729	3,101
National	7,494	7,095	7,143	7,221	7,271	7,278	5,984	5,642	6,594
Share	47%	50%	50%	51%	51%	50%	56%	48%	47%

Sources: China Statistical Yearbook & own calculations

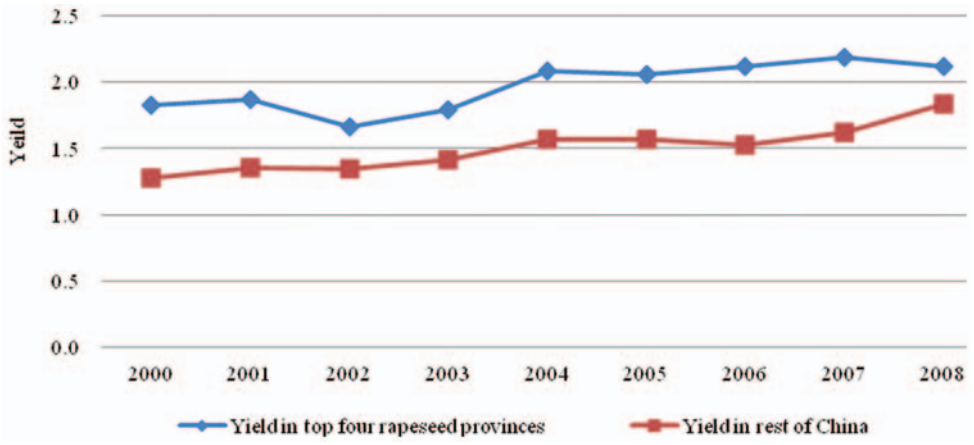

Figure 2: Average rapeseed yields in four provinces and the rest of China (t/ha)
Sources: China Statistical Yearbook & own calculations

past few years, rapeseed still accounts for about 13% of total acreage of Hubei and therefore remains the highest proportion in the four provinces. In Anhui the share of rapeseed acreage was almost stable from 2000 to 2005, but it decreased sharply to the lowest point in 2007. Sichuan evolved differently because here from 2000 to 2007 the share of rapeseed acreage was almost flat at around 8% to 9%. In Jiangsu a similar situation can be found, only in 2007 the acreage was reduced significantly. From Figure 1 it appears that regions with a relatively high share initially experienced a sharp decline after 2004 while regions with only lower shares in the beginning of the period analyzed here where either stable or just saw a moderate decline.

Between 2000 and 2007 rapeseed yields continuously increased with an annual growth rate of about 3.1%. In 2008, a slight drop in the four main provinces occurred (see Figure 2). With yields of about 2.5 t/ha, farmers in Jiangsu have been the most productive. In the other three provinces yields only reached a level of about 1.9 to 2 t/ha (see Table 2). However, since in these regions initial yields in 2000 were lower compared to Jiangsu the growth rate was still significant.

From Figure 2 it can be concluded that in the period examined, the growth in yields was fairly constant. The growth outside the leading regions was slightly lower but also significant. Hence, it seems likely that there is room for further growth in yields. This is even more likely because in other parts of the world, for instance in Europe, it is well known that rapeseed – provided climatic conditions and agronomical treatment are adequate – offers much higher yields in the range of 3 to 4 t/ha or more. Of course such a development will only occur with high yielding varieties and optimized farming practices, including access to modern plant protection inputs.

In the main rapeseed producing provinces, farmers plant rapeseed between the beginning of September and early October. They harvest in late April and early May of the next year. Wheat has basically the same season as rapeseed. As regards cotton, its growth cycle is from April to September. After the harvest of winter crops

Table 2: Rapeseed yields in main production provinces (t/ha)

Yield	2000	2001	2002	2003	2004	2005	2006	2007	2008
Jiangsu	2.20	2.14	1.96	2.13	2.43	2.40	2.45	2.52	2.48
Anhui	1.63	1.87	1.52	1.51	1.90	1.91	1.98	2.10	2.09
Hubei	1.71	1.74	1.31	1.59	1.98	1.86	1.92	2.09	1.97
Sichuan	1.77	1.71	1.87	1.93	2.03	2.07	2.12	2.04	2.14
Average of 4 provinces	1.83	1.87	1.67	1.79	2.09	2.06	2.12	2.19	2.12
Average China	1.52	1.60	1.48	1.58	1.81	1.79	1.83	1.87	1.84

Sources: China Statistical Yearbook & own calculations

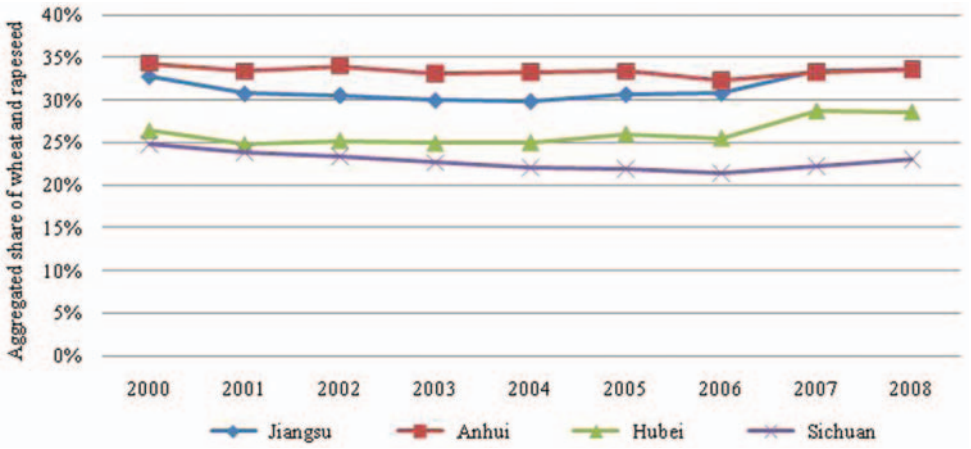

Figure 3: Aggregated share of wheat and rapeseed acreage in total arable land
Sources: China Statistical Yearbook & own calculations

such as wheat or rapeseed, in July or August, farmers usually plant their fields with soybeans, which normally are harvested in November. In the regions considered here, most farmers apply transplantation of rapeseed to make full use of land. That means they use a small part of their field for a very high density seeding in order to get the plants started. Once they have reached a certain growth stage and the previous crop has been harvested, the small seedlings are transplanted to the field at a conventional density.

Based on this information, from a grower's perspective wheat is the most suitable alternative to rapeseed because the growing season is very similar. Consequently, wheat qualifies for the use as the benchmark for the economic analysis of the competitiveness of rapeseed. The hypothesis of wheat being the most likely alternative to rapeseed from an agronomic perspective can be further tested by looking at the evolution of the acreage for the two crops. Since they are really close substitutes, any increase in the acreage of one of the crops should go hand in hand with a decrease in the other – and vice versa. A respective figure has been generated in which the acreage of both crops has been added (see Figure 3). What shows up is that the total acreage of the two crops is almost flat in all provinces. Since we know from Figure 2 that rapeseed acreage went down significantly from 2004 onwards, it can be assumed that indeed both crops are most likely close substitutes.

As demonstrated in the above, a significant change in Chinese cropping patterns took place as far as key areas for rapeseed production are concerned. Furthermore it has been shown that rapeseed and wheat are close substitutes in terms of production systems in the respective provinces. Therefore it is appropriate to use wheat as a benchmark in order to explore the hypothesis of diminishing economic competitiveness of rapeseed as the main reason for the decrease in its acreage.

3. Economic data to explain changes in Chinese rapeseed acreage

As mentioned in the introduction, figures about regional gross margins and regional labour cost as key farm level economic parameters will be used to explain the observed change in cropping patterns in the key rapeseed producing regions. This next chapter deals with this analytical step.

The impact of labour cost

As a first step, the number of hours used in order to produce one hectare of rapeseed and wheat respectively is analyzed. Since the relative importance of labour input for the two crops is of relevance, a ratio has been calculated by using the labour input for wheat as the standard. Hence, the number of hours spent in rapeseed has been divided by the hours spent in wheat. In Figure 4, bars above 1 indicate a higher labour input in rapeseed compared to wheat. As can be seen in this graph, except for one year in the Hubei province and the Sichuan province, all ratios have been higher than one in all provinces all the years analyzed in this article. The very high ratios in the Jiangsu province can be explained by the fact that in this province mechanization of wheat production is much higher than in the other provinces in this comparison. Consequently the labour input is lower in wheat and hence the ratio increases.

The systematic difference in labour input between the two crops is caused by differences in mechanization. Pre-seeding and transplanting of seedlings is obviously a very labour intensive exercise. At the same time there is no transplanting in wheat. Since we intend to explain a change of cropping patterns over time, the simple difference in labour input cannot be a cause because this disadvantage of rapeseed production relative to wheat has been in place from the beginning. However, in case the economic value of this difference in working hours increased over time, it seems reasonable to assume that the increasing difference in labour cost has caused farmers to move away from rapeseed cultivation.

As can be seen in Figure 5, wage rates in rural areas did indeed increase significantly from 1.2 US$/day[3] in 2000 to 3.1 US$/day in 2008. This change equals more than 150%. Only the smaller part of that increase in US$ terms is caused by the depreciation of the US$ relative to the Yuan: Expressed in national currency, wage rates went up roughly 100%. It should be noted that the

[3] In early October US$1 was approximately equivalent to £0.62 and €0.77 (www.xe.com).

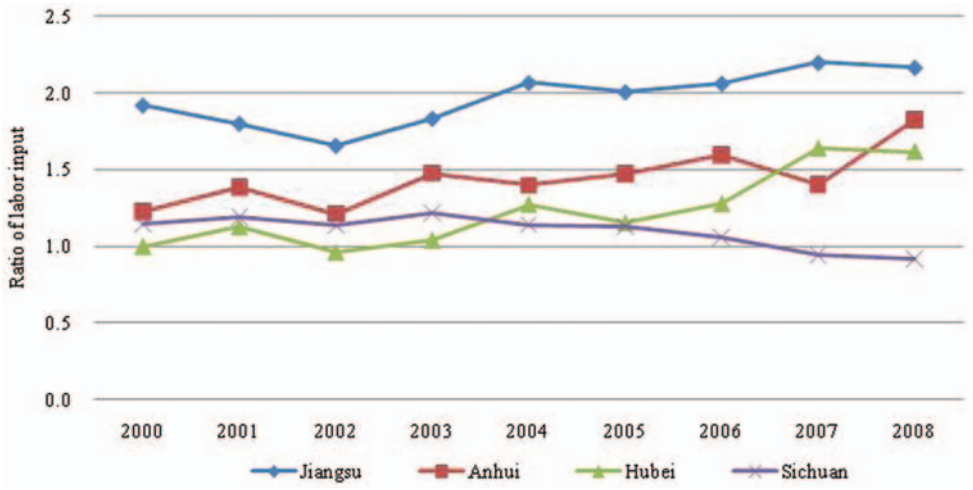

Figure 4: Ratio of labour input in rapeseed production relative to wheat
Sources: Compilation of National Cost-Benefit Data of Farm Products & own calculations

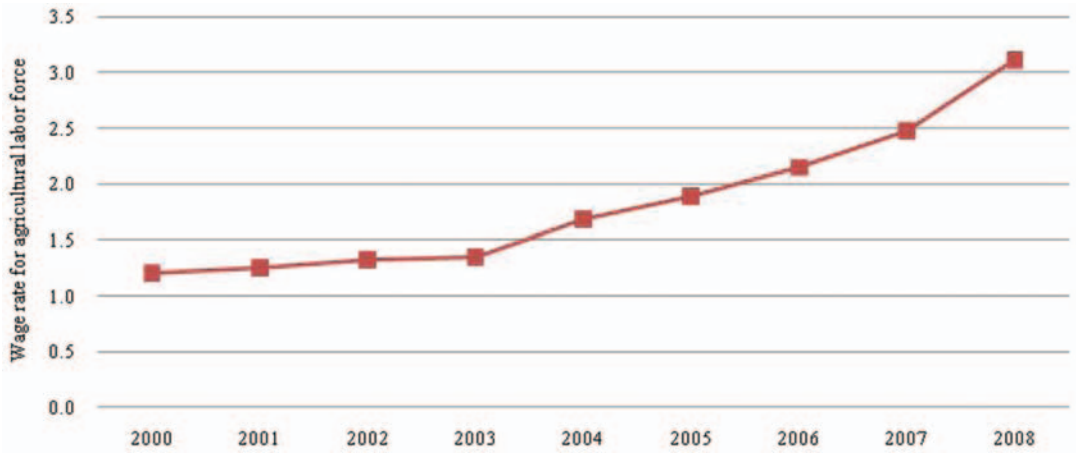

Figure 5: Wage rate for agricultural labour force (US$/day)
Sources: Compilation of National Cost-Benefit Data of Farm Products & own calculations

decrease of rapeseed acreage started in 2004 – exactly the same period in which a particularly sharp increase in wage rates occurred: More than 90% of the entire increase in wage rates took place from 2003 onwards. Based on this information, it seem very likely that increasing opportunity cost has caused farmers to move away from a rather labour intensive crop such as rapeseed to a less labour demanding one such as wheat.

The impact of gross margin changes

Besides changes in labour cost, the evolution in gross margins could be a driving force for changes in cropping patterns. The gross margin (defined as gross revenue minus direct operating inputs which include cost of fertilizer, plant protection, and contractors) are displayed in Figure 6 for both crops and each of the regions analyzed.

Over time a steep increase in gross margins took place for both, rapeseed and wheat grown in all regions analyzed. Values went from 200 US$/ha in 2000 to 1,000 US$/ha and more in 2008.

From 2001 and 2002 respectively onwards wheat gross margins tend to be as high as or even higher than rapeseed gross margins in most of the cases.

In 2007 - and even more pronounced in 2008 - a strong rebound of rapeseed gross margins occurred.

4. Specification of an econometric model and results

Model

As explained above, economic theory suggests that farmer's decision regarding cropping patterns are driven by the incentive to maximize profits from the scarcest factor, which is land. Under the assumption that there is no major difference between different crops in terms of machinery and labour inputs required, gross margins are considered to be a reliable proxy for profitability of land use. As long as it can be assumed that crop production in general is profitable – resulting in a more or less stable total land use – it is not the absolute value of gross margins that matter but rather the ratio. Changes in relative profitability of crops will ultimately lead to changes in cropping patterns; hence the ratio between gross margin for wheat and rapeseed (GMR) is used as one independent variable. The expectation is that the higher (lower) the value of 'GMR', the higher (lower) the competitive position of rapeseed relative to

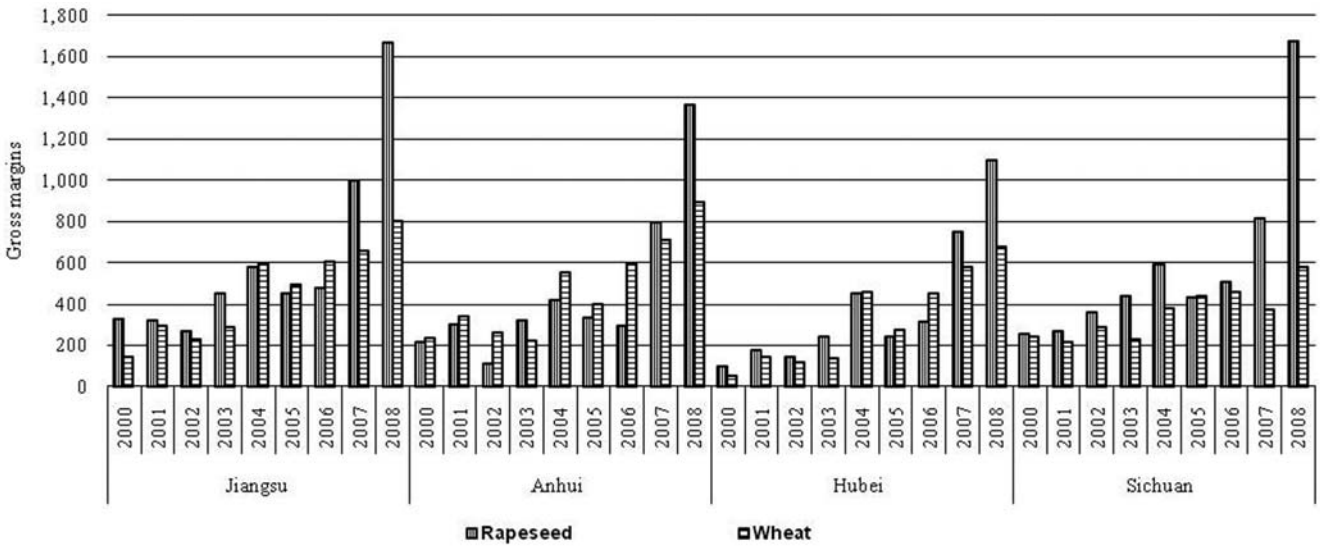

Figure 6: Evolution of gross margins from Rapeseed and Wheat in four key provinces (US$/ha)
Sources: Compilation of National Cost-Benefit Data of Farm Products & own calculations

wheat. A low (high) competitive position of rapeseed will lead to a decrease in the share of rapeseed in total acreage (CR).

Since there is strong evidence that the assumption regarding uniform non-cash cost across relevant crops is not true at all, the differences in labour input and respective cost have to be taken into account. In an ideal situation differences in labour cost would be used to set up an econometric model. However, there is no such data available for a broad range of farms in key rapeseed producing regions of China. And since the majority of farms use family labour, there is no easy access to labour cost anyhow. Therefore the model uses the ratio between labour input in rapeseed and in wheat (LIR) as a proxy for differences in labour cost. The economic hypothesis is that the higher (lower) the ratio the lower (higher) the incentive to grow rapeseed relative to wheat.

Against this background the econometric model is specified by using the log-log regression model. $\log(CR)=\alpha+\beta\log(GMR)+\gamma\log(LIR)+\varepsilon$. Where CR is the share of rapeseed acreage in the total acreage, GMR is gross margin of rapeseed/gross margin of wheat, LIR is ratio of labour input in rapeseed production relative to wheat production, α is intercept coefficient, β and γ are slope coefficients, and ε is the error term. In order to reduce the effect of co-linearity, a double logarithmic model is used.

Due to the lack of relevant future markets the growers' decision making process is most likely described best as a 'naive expectation behaviour' (Wang Q. 2011): Crop profitability in a given year is used as an indicator for profitability of crops in the following year. Therefore the model is using t-1 values to explain CR_t data.

Data

The subsequent analysis is based on data from the following sources: 1) *China Statistical Yearbook* (Zhongguo Tongji Nianjian) from 2001 to 2008, edited by National Bureau of Statistics of China. 2) *National Compilation Cost-Benefit Data of Farm Products* (Quanguo Nongchanpin Chenben Shouyi Ziliao Huibian) from 2001 to 2009, edited by National Development and Reform Commission People's Republic of China . These data have been generated by price monitoring authorities at all national levels and the National Operating Department. This department surveyed about 1,500 counties in which 60,000 farmers have been interviewed in total.

Since panel data are used in this model it has to be tested for random effects. Panel data models are based on the assumption that random effects are uncorrelated with the explanatory variables. One method for testing this assumption is to employ a Hausman (1978) test to compare the fixed and random effects of coefficients (Software used: E-Views). The probability is 0.96 which is well above the 0.1 threshold, consequently statistics provide evidence to accept the null hypothesis that there are correlated random effects (see table 3).

Results

Results in Table 4 suggest only limited evidence for the hypothesis that gross margin ratios and labour input ratios have an impact on rapeseed production in the top four rapeseed producing Chinese provinces. While the impact of the labour input ratio is significant on a 5% level the gross margin ratio impact is statistically not significant. Moreover, the low R^2 for the gross margin ration has to be mentioned; it indicates that other factors than those measure here influence growers decision. However, the magnitudes as well as the signs

Table 3: Correlated Random Effects - Hausman Test

Test cross-section random effects			
	Chi-Sq. Statistic	**Chi-Sq. d.f.**	**Prob.**
Test Summary Cross-section random	0.084	2	0.96

Table 4: Pooled EGLS (Cross-section weights) Parameter estimates for share of rapeseed in selected provinces.

Variable	Coefficient	t-Statistic
Constant	2.44	10.22***
$\log(GMR_{t-1})$	0.09	1.31
$\log(LIR_t)$	−0.45	−2.63 **
Random Effects (Cross)		
JS_C	−0.09	
AH_C	0.01	
HB_C	0.37	
SC_C	−0.29	
R^2	0.27	

Sources: Own calculations. ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. JS, AH, HB and SC are abbreviations for Jiangsu, Anhui, Hubei and Sichuan province.

of the estimated parameters make economic sense: (a) an increase in the gross margin ratio by 1% causes the share of rapeseed acreage in the subsequent year to go up by 0.09%. (b) An increase in the relative labour input in rapeseed compared to wheat by 1% in a given year will cause a reduction of the share of rapeseed acreage in the subsequent year by 0.45%.

The lack of statistical significance of gross margin ratios may be caused by the fact that the hypotheses that previous gross margin ratios influence growers cropping decisions in the subsequent year is too simple. Alternatively a possible explanation is that grower's decisions are to a large degree caused by non-economic factors. The strong impact of relative labour input does match with the fact that current production systems in rapeseed are rather labour intensive and at the same time opportunity cost for growers went up significantly. According to the eleventh National People's Congress at the fifth meeting of the government work report (2012), more than 36% of Chinese growers are working also outside the agricultural sector.

5. Summary and conclusions

Statistical data show that Chinese rapeseed production is not only important in terms of acreage but is also rather concentrated: Only the four provinces Hubei, Anhui, Jiangsu and Sichuan account for more than 50% of the entire rapeseed production. Furthermore a significant and more or less uniform decrease in rapeseed acreage from 2004 to 2007 can be detected. Only in 2008 a limited recovery in rapeseed production was realized.

In order to explain said evolution, driving factors for microeconomic decision making at farm level are tested as a main cause. In a first step the relevant alternative crop from an agronomic perspective is defined, which happens to be wheat. Since on Chinese smallholder farms labour input is much higher for rapeseed compared to wheat and opportunity cost for labour increased significantly in previous years, labour cost can be seen as a driving factor for the decrease in rapeseed acreage.

The specified regression model provides only limited evidence for the suggested impact of changes in the gross margin ratio while of the impact of labour input ratios on the share of rapeseed acreage turned out to be significant. However, the signs of both estimated parameters do make economic sense.

Based on the data available, it seems reasonable to assume that Chinese smallholders' decision making – even though heavily influenced by the grain regulation polices of the state – is also driven by labour cost. Furthermore, it seems likely that wage rates for migrant workers are a realistic proxy for the opportunity cost of family labour in the regions analyzed.

In turn that means that Chinese rapeseed production not only needs higher yielding rapeseed varieties and/or higher rapeseed prices relative to wheat, but also less labour intensive seeding technologies in order to return to former levels of acreage. Whether the relatively strong growth in rapeseed yields which have been realized in the past and improving mechanization of rapeseed will continue and hence eventually offset some of the recent economic shortcomings of rapeseed production as analyzed here, remains to be seen.

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