Rural Labor Allocation and Farm Technology

Yunbo Zhou*, Steven Lim**, and Michael P. Cameron***

Abstract

Whether the agricultural and rural industrial sectors compete for key resources, particularly labor, is an important policy question. This paper investigates the determinants of the inter-sectoral flow of labor between farm and off-farm activities, using data from Tianjin, China. Specifically we investigate whether the labor flows are explained by the level of agricultural technology employed by rural households, where the technologies can have positive or negative impacts on farmers' incentives to remain on the farm. Our model specification and data set allow us to bridge macroeconomic and microeconomic issues in the labor allocation decision that do not appear to have been addressed elsewhere.

JEL: J22, Q12, Q16
Keywords: rural labor, migration, off-farm employment, agricultural technology, China

The authors gratefully acknowledge the very helpful and insightful comments from Mark Holmes.

1. Introduction

The structural transformation of the rural economy has, and continues to be, one of the most important development issues for many low-income countries (Reardon et al., 2007). Mellor's (1986) highly influential work highlights the pivotal role of technology in spurring agricultural output, which in turn contributes to the growth of rural industry. This view has been reflected in actual policy. In the mid-eighties, with strong growth based on farm technologies and institutional reforms, China's agricultural sector supported rural industrial growth via expanding labor and capital transfers (Findlay and Watson, 1992). Yet within a few years China retreated partially from this approach,
fearing excessive labor losses from agriculture and a compromise of food security. Such policy u-turns impose significant dislocation costs on an economy. Given that China’s post-reform transfer of labour from agriculture to rural industry was the largest in recent world history (Kalirajan and Wang, 1994), the economic drivers of labor switching are an important research issue.

Here the literature seems poorly developed. Mellor’s (1986) work on agricultural–rural industrial transformation prompted extensive research (e.g., Ranis and Stewart, 1993). Such macro- or sectoral-focused studies discuss output and price changes, but offer little formal modeling of the household decision to switch employment between farm and off-farm activities. In contrast, a more recent literature investigates the role of micro variables affecting labor decisions to move between sectors. The variables typically include household land use, education levels, age, gender and the number of migrants within the household (e.g. Huang et al., 2009; Zhao, 1999). There is no explicit modeling of changes to output prices as people switch jobs and output changes sector-wide. In some econometric specifications of labor reallocation, intersectoral output prices are not included at all (e.g., Rizov and Swinnen, 2004). Significantly, agricultural technology is not tested as an explanatory variable in employment switching. Thus there is a gap between the earlier macro-level work on rural structural transformation, based on advances in agricultural technology, and the literature on micro-level labor decisions that relate to income and job opportunities, but which ignores the impact of agricultural technology on promoting the opportunities via structural transformation in the first place.

Our aim is to blend the micro and macro approaches. We focus on the role of agricultural technology in influencing the incentives to remain as a farmer or to shift to industrial work, where the incentives are also determined by sectoral feedback via price and aggregate output changes that may be determined by agricultural technology.

2. Empirical illustration from Tianjin, China

Our analysis of labor transfer uses data from the 2003 Rural Household Survey provided by the Tianjin Rural Social and Economic Survey Team. A total of six hundred households from four districts and three counties of Tianjin province were surveyed. The villages and households were selected using a stratified sample. The statistical descriptions of the districts and counties included in the sample are presented in Table 1.

Of the 600 households surveyed, 15 households had no laborers, 197 households had only farm laborers, 135 households had only off-farm laborers, and 253 households had both farm and off-farm laborers. After eliminating the 15 households without laborers, the sample provides 585 observations. We divide the total sample into two groups: 197 ‘pure farming’ households that only had farm laborers and 388 ‘off-farm labor’ households that had at least one person employed in off-farm labor.

To investigate the role of farm technology in influencing labor allocation between farm and off-farm (industrial) employment we use a simple regression model. The dependent variable is the intensity of labor allocation, namely the number of months spent on farming activities minus the number of months spent on non-farming activities, all divided by the sum of months spent on farming and non-farming activities. The intensity of labor allocation variable takes on a value between +1, where all household production activities are farming, and -1, where all household production activi-
ties are non-farming.

Assuming non-separability of consumption and production decisions (Benjamin, 1992), one important determinant of household labor allocation is the relative monetary incentives to undertake farm or non-farm work (such as non-farm self-employed activities). In our model, the explanatory variable that captures this effect is the ratio of profit difference, namely the net household income from farming minus that from non-farm production activities, all divided by the sum of farm and non-farm net incomes. This variable incorporates both the output and price changes discussed earlier. Such a specification has been used elsewhere in simulation models (e.g., Grasso, 1998). In econometric models of agricultural output relating to China’s economic reforms, output price has been used to represent labor incentives (Lin, 1992). The advantage of our data set is that, by using net incomes, we are able to better capture labour incentives to remain in agriculture than by using output price alone.

Our data set hence allows us to investigate motivational issues that were not addressed in earlier, important papers (such as Lin, 1992). In particular, investment in productive capital in agriculture and in agricultural technology raises the marginal product of labor in agriculture. This makes agriculture relatively more profitable than off-farm employment, shifting the profit difference in favor of farm income (a productivity effect). Further, this change in the profit difference ratio affects the intersectoral allocation of labor, shifting labor to agriculture and, provided the marginal revenue product of labor remains positive, further increasing farm income. However, higher farm output in aggregate resulting from higher productivity and labor reallocation towards agriculture could depress the price of farm output. This would reduce farm incomes, shifting the profit difference in favor of non-farm income (a price effect). The key question is which of the productivity effect or price effect is larger within the relevant range for farm households in rural China.

Other explanatory variables in our model include a vector of variables from the farm’s production function (including crop area, the number of farm laborers, and human capital), a vector of capital and technology variables (including productive agricultural assets, productive non-agricultural as-

| Table 1: Descriptive Statistics for Sampled Districts and Counties |
|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|                     | Xiqing District      | Beichen District    | Wuqing District     | Baodi District      | Ninghe County       | Jinghai County       | Ji County           |
| Per capita GDP (yuan) | 32681               | 30784               | 12502               | 13466               | 18686               | 15358               | 10838               |
| Total rural households (000s) | 74.5             | 64.1                | 195.3               | 151.1               | 76.6                | 129.7               | 183.6               |
| Total rural population (000s)  | 229.1             | 198.3               | 696.0               | 554.3               | 282.6               | 426.3               | 693.2               |
| Total rural laborers (000s)    | 106.0             | 80.9                | 363.3               | 254.3               | 112.1               | 156.1               | 316.5               |
| Off-farm laborers (000s)       | 68.0              | 50.5                | 157.5               | 118.7               | 48.5                | 80.6                | 152.2               |
| Proportion of rural labor force in off-farm employment (%) | 64.2              | 62.4                | 43.4                | 46.7                | 43.3                | 51.6                | 48.1                |
| Number of town and village ownership enterprises | 644               | 3299                | 405                 | 295                 | 161                 | 604                 | 523                 |
| Cultivated area (ha.)          | 16137             | 18492               | 90690               | 77163               | 39451               | 69215               | 54184               |
| Sample size                    | 60                | 60                  | 100                 | 100                 | 80                  | 100                 | 100                 |

Data Source: Tianjin Statistical Bureau (2003).

1 And provided non-separability holds, this increase in labor allocation to agriculture will come at least partially from the household’s own labor supply. In Tianjin the number of households that employ farm labourers is around 1–2%.
sets, and whether the farm has some proportion of their fields covered which is a proxy for the level of agricultural technology), and a vector of confounding variables which may have some effect on labor allocation decisions (such as proximity to county center).

The explanatory variables of interest in this paper are the vector of capital and technology variables, and in particular the sign and significance of their coefficients. The econometric model was estimated using OLS regression with standard errors corrected for heteroskedasticity.

The estimated results for the econometric model are shown in Table 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit difference</td>
<td>0.0481**</td>
<td></td>
</tr>
<tr>
<td>Area of crops planted (mu)</td>
<td>0.0013***</td>
<td></td>
</tr>
<tr>
<td>Proximity to county center (1 = within 5km)</td>
<td>-0.3312****</td>
<td></td>
</tr>
<tr>
<td>Education (highest among laborers)</td>
<td>-0.0427***</td>
<td></td>
</tr>
<tr>
<td>Non-agricultural assets value</td>
<td>-0.0238*</td>
<td></td>
</tr>
<tr>
<td>Agricultural assets value</td>
<td>0.1708***</td>
<td></td>
</tr>
<tr>
<td>Use of covered fields (1 = yes)</td>
<td>0.5440***</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.3182***</td>
<td></td>
</tr>
</tbody>
</table>

N 585  
F 42.94***  
R² 0.3014

* weakly significant at p < 0.1; ** significant at p < 0.05; *** significant at p < 0.01

2 The maximum number of years of education of any of the laborers is used as a proxy. An alternative proxy, the average number of years of education of all laborers in the household resulted in qualitatively similar results.

3 The value of productive fixed assets for farming, forestry, animal husbandry and fishery. They include farm buildings, all kinds of agricultural tractors, livestock for production and milk, etc.

4 The value of productive fixed assets for industry, construction, transport, wholesale, social service, education etc., including buildings and machinery.

5 A binary variable set to 1 where the village was within 5km of the county center.

6 The direction of causality in the relationship between the intensity of labor allocation towards farming and the ratio of profit difference is not simple. While increased profit difference increases the incentives for engaging in farm production, increased farm production increases the profit difference. However, an alternative specification of the model, using seemingly unrelated regression with both profit difference and labor intensity as dependent variables, produces qualitatively similar results. Similarly, specifications including different sets of explanatory variables also produce qualitatively similar results. Therefore, we concentrate here on the simple model specification.
household and the value of non-agricultural productive assets also have significant negative effects on the intensity of labor allocation, reflecting that households with members who are better educated will be more likely to be able to take advantage of non-farm employment, and reflecting a bias towards allocation of household labor to non-farm production when the household employs more capital to non-farm production.

Of more interest in the current paper are the sign and significance of the other variables in the capital technology vector, in particular the value of productive agricultural assets and the use of covered fields. Both agricultural assets value and the use of covered fields have positive effects on the intensity of labor allocation (towards agriculture) after accounting for other variables in the farm’s production function. This is an important finding, suggesting that agricultural technology impacts on the labor allocation decision of households, independent of the effect of other incentives.

3. Conclusion

In this paper we have estimated the relationship between agricultural technology and farm–non-farm labor choice in the form of the intensity of labor allocation, accounting for other variables expected to affect the farm supply curve facing rural households. In our estimations, using data from rural Tianjin province in China, the relationship between job switching towards farming and farm technology is both significant and positive in the relevant range. Our results suggest that the positive effect of investment in agricultural technology on farm productivity is greater than the negative effect on farm prices.

References
Ranis, G. and F. Stewart (1993). Rural nonagricultural activities in development: theory and appli-


