From Transition to Development: The Economics and Policies of Rural Transition in East Asia, the Former Soviet Union, and Central and Eastern Europe (Scott Rozelle, University of California, Davis, presiding)

Responsiveness, Flexibility, and Market Liberalization in China's Agriculture

Alan de Brauw, Jikun Huang, and Scott Rozelle

Although the impact of decollectivization, the main incentive-increasing reform in rural China in the late 1970s and early 1980s, is well documented and fairly well understood (Lin), attempts to quantify the gains or the mechanisms from market liberalization, the second part of rural reforms, have been largely unsuccessful. Part of the problem may be the period of analysis and the inability of the various research approaches to separate efficiency gains of market reform from overall gains in the reforming economy. For example, Wen found total factor productivity (TFP) growth stopped after 1985, a trend he blames on the failure of market-liberalization reforms. Holding constant the effect of technology, Huang et al. find that TFP growth restarts in the 1990s, but is at most only in part linked to increased liberalization of the economy. Fan uses frontier methods to decompose the efficiency gains of Jiangsu provincial farm producers in the late reform era and concludes that there have been at most only limited gains from market liberalization.

If one were to take the findings of this admittedly scant literature seriously, it would appear as if there is at most only a relatively small impact from market reforms in China. We believe there are three possible, but only one plausible, explanations for the findings. First, if market liberalization actually contributes little to no growth or increases in output or incomes, this would, of course, in part explain why economies that lead reform with market liberalization do not experience significant gains. Theory and the experiences of other economies in other settings, however, would argue against such an interpretation. Second, it could be that China's agricultural market liberalization has just proceeded so slowly that it is still too early for output to have been positively affected by market liberalization. However, as seen above, the record on the market expansion and the observations of many researchers would not support this view.

If the first two explanations are not correct, then, it leaves us with just one explanation. It might be that the methods previously used to measure the behavioral changes of producers have not fully captured the effect of market liberalization. In fact, almost all of the previous literature on this subject has tried to capture the effect of market liberalization by examining the residual growth of output after other sources of growth have been accounted for. It may be that we are missing the part of the efficiency gains because of the presence of measurement error or other factors.

The goal of this paper is to construct more carefully a way to measure how market liberalization affects the behavior of producers in transitional economies. While our study is limited to the case of China's agricultural sector and its reforms, we argue that this is a good laboratory to study market liberalization. Leaders were purposely deliberate in their timing of unleashing the market reforms, so we know when to begin to look

Alan de Brauw and Scott Rozelle are graduate student and associate professor, respectively, in the Department of Agricultural and Resource Economics, University of California, Davis. Jikun Huang is director of the Center for Chinese Agricultural Policy, Chinese Academy of Agricultural Sciences. Alan de Brauw is also a fellow, SSRC Program in Applied Economics.

Authors are in alphabetical order and the senior authorship is shared.

This paper was presented in a principal paper session at the AAEA annual meeting (Tampa, FL, August 2000). Papers in these sessions are not subjected to the Journal's standard refereeing process.

for the effects. Moreover, there are few places where transition has been as successful as China's agricultural sector, so if it is possible to measure the behavioral effects of liberalization, China is a good case study. To meet our goal, we pursue two objectives. First, we delineate two effects on producers that nations can expect from market liberalization and we lay out a framework for measuring them. Second, we estimate the liberalization effects on China's agricultural producers in the late 1980s and 1990s.

Transition, Markets, and Behavior

Rozelle shows that the sequencing of agricultural reform policies followed the gradualism strategy of China's more general, economy-wide reforms that McMillan and Naughton describe. In the initial stages of reform, leaders consciously restricted the promotion of market-based economic activity, allowing at most the exchanges of minor products (e.g., minor fruits and vegetables) in sharply circumscribed regions. Not until 1985, after the completion of decollectivization, did policy makers begin to encourage market activity for more important commodities (e.g., grain), although initially market activity only occurred within the framework of China's renowned two-tier price system (Sicular). Leaders did not fully commit themselves to more complete market liberalization until the early 1990s, more than a decade after the initiation of the household responsibility system (HRS). From this description, it is clear that China's reforms fall into two distinct stages: the incentive reforms that dominate the period from 1978 to 1984, and a period of gradual market liberalization that begins in 1985 and extends through the 1990s.

While the two parts of the reform received equal relative attention by policy makers in each period, the record on measuring reform effects is not the same. The literature carefully documented the returns to increased incentives in China's early stages of reform (Lin) and concludes that HRS led to sharp increases in output and greater efficiency. As seen in the Introduction, however, there was much less success in measuring how liberalization increased efficiency. Since it appears likely that part of the reason for this lack of success is because of methodological shortcomings, we will to try to establish a framework for understanding how the emergence

of markets of exchange would be expected to affect behavior.

Returns to Markets

Absent or poorly functioning markets impose two constraints on economic producers. First, when markets are not well developed, or when policies or institutional constraints raise transaction costs and limit market-based exchange, producers lack the *flexibility* to change the allocation of their productive assets and choice of enterprises. Second, as prices and other factors in the economy change, producers are less *responsive* when shifting their variable inputs. We look at flexibility and responsiveness below.

Flexibility is defined to be a characteristic of the producer's decision-making environment that refers to the speed by which certain types of inputs (quasi-fixed factors) adjust to changes to exogenous factors, such as prices, the level of publicly provided infrastructure (e.g., irrigation), etc. It is a measure of efficiency in which the metric is ultimately measured in the years that it take the producer to move from the original production point (before the price change) to the point of long-run optimality (after the price change). If (1) markets were frictionless, or if there were good information, (2) the investment of the input involved no fixed costs, and (3) there were no legal, regulatory, or policy restrictions governing input use, then the profit-maximizing producer would shift from the initial point to the point of long-run optimality in one period. When the producer can do this, the input is said to be a "variable input." However, when faced with a price change, if the producer cannot shift input use all of the way to the new profit-maximizing point, there is an efficiency loss. Hence, we define one of the gains to market liberalization as the increase in speed of adjustment that arises from reductions in frictions in the adjustment process of quasi-fixed inputs after a change in the economic environment. In China, we should expect that if market-liberalization policies have been effective, the flexibility of the economy should have improved after 1985.

Certainly, there is reason to believe that China's producers have begun operating in more flexible environments in the late reform period, especially with regard to their choices of sown area and labor. In the late reform

period, as quotas have fallen and labor markets and commodity markets have developed (Sicular), the scope for farmer decision making has expanded greatly. In particular, the rise of rural industry and increased opportunities to work off the farm in areas near the farmer's home village conceivably have had a large impact on the flexibility of labor use.

Lack of well-functioning markets also may limit the *responsiveness* of farmer-supply and input-demand decisions. According to one of Marshall's fundamental principles of demand, the more variable factors of production there are, the more responsive producer choices are to changes in price and other fixed factors. If newly emerging markets allow farmers to choose more of their inputs, the increased scope for substitution among inputs will make farmers at least as responsive, *ceteris paribus*. Responsiveness changes will show up in the measures of estimated changes between the early and the late reform period, such as changes in own-price factor demand elasticities.

Measuring Behavioral Effects of Market Liberalization

As discussed above, the increase in the speed by which quasi-fixed factors adjust corresponds to increased *flexibility*. To estimate the adjustment speed of quasi-fixed factors while considering the main sources of production growth, a theoretical-empirical framework that explicitly accounts for the elements that facilitate or constrain producers from adjusting inputs and outputs to their optimal levels in response to exogenous shocks is needed. Such approaches exist, including the agricultural treadmill, fixed asset theory, and adjustment-cost models (Lucas, 1967). We choose the adjustment-cost approach as it produces measures that are particularly appropriate for understanding how adjustment costs change as the opportunities for exchange emerge and the barriers are reduced. In the adjustment-cost model, factors that are slow to adjust are called quasi-fixed inputs and are endogenous variables; their levels and rates of change are in part chosen by the producer in response to changes in exogenous factors. Quasi-fixed inputs affect production in both the short and the long run. A theoretical and empirical framework is described in Epstein (1981), Warjiyo (1991), and de Brauw, Huang, and Rozelle (2000).

Empirical Model for Measuring Flexibility

To measure flexibility and responsiveness in China's agriculture, we estimate a complete system of dynamic input-demand and output-supply equations, derived from the normalized quadratic-value function (shown in Warjiyo, 1991):

$$(1) \quad \Delta K_{(t)} = B_{12} + (rU + R)K_{(t-1)}$$
$$+ rRGp_{(t-1)} + rRLw_{(t)}$$
$$+ rRCq_{(t)} + T_{12}Z_{(t)} + e_{12(t)}$$

$$(2) \quad L_{(t)} = B_{03} - rFp_{(t-1)}$$
$$- rBw_{(t)} - rL'q_{(t)} - N'K^*_{(t)}$$
$$- T_3 Z_{(t)} + e_{3(t)}$$

$$(3) \quad Y_{12(t)} = B_{45} + rAp_{(t-1)}$$
$$+ rF'w_{(t)} + rG'q_{(t)} + H'K^*_{(t)}$$
$$+ T_{45}Z_{(t)} + e_{45(t)}$$

$$(4) \quad Y_{3(t)} = B_{06} + ra_4 K^*_{(t)}$$
$$- 0.5rp'_{(t-1)}Ap_{(t-1)} - 0.5rw'_{(t)}$$
$$\times Bw_{(t)} - 0.5rq'_{(t)}Cq_{(t)}$$
$$- rp'_{(t-1)}F'w_{(t)} - rp'_{(t-1)}G'q_{(t)}$$
$$- rw'_{(t)}L'q_{(t)} + 0.5rK'_{(t-1)}$$
$$\times DK_{(t-1)} - \Delta K_{(t)}DK_{(t-1)}$$
$$+ ra_5 T_{60}Z_{(t)} + Z_{(t)}$$
$$\times T_{61}K^*_{(t)} + e_{6(t)}$$

where parameter matrices in the equations above are defined in de Brauw, Huang, and Rozelle (2000). The conditions for consistent aggregation and those to impose economic behavior are found in Warjiyo (1991).

Our empirical model consists of three crops; Y_{12} is a two-element output vector for wheat and maize, and Y_3 is cash-crop output. Prices for wheat and maize p, the of the variable input (fertilizer) w, and the two quasi-fixed input prices (for labor and for sown area) q, are normalized by the cash-crop price to satisfy homogeneity. The Z-vector is comprised of three shifter variables: national research stock, irrigation capacity, and a variable reflecting the effect of institutional incentive reform. Provincial dummy variables account for fixed, province-specific effects.

As discussed above, we consider sown area and labor to be quasi-fixed inputs. The R matrix in equation (1) and the profit equation

(not shown—see Warjiyo) is the adjustment matrix. The coefficients on the diagonals of the R matrix (R11 and R22) are called adjustment cost or flexible accelerator parameters. The parameters are estimates of the average, one-period proportional adjustment of a quasi-fixed factor to its long-run optimal level that is made in response to a change in an exogenous variable. They can therefore be interpreted as explicit measures of the flexibility of quasi-fixed factors. To measure the *change of flexibility*, we interact a dummy variable (zero for the early reform period, 1975–84, and one for the late reform period, 1985–95) with all of the variables in equations (1) and (2) associated with the adjustment parameters. The parameters associated with the interaction term (denoted R11D and R22D) measure how much more or less flexible quasi-fixed factors become in the market-liberalization period.

The adjustment-cost model generates two useful sets of relationships between the choice variables (i.e., variable and quasi-fixed inputs and outputs) and exogenous factors, one of which is used in this paper. Short-run elasticities measure the one-period response of choice variables to shifts in prices and policy variables, including *direct and indirect changes* of variable inputs and outputs. *Indirect changes* occur through the partial quasi-fixed factor response of the producer. As quasi-fixed factors do not fully adjust in one period, the indirect change in the variable input or output amount reflects the speed of adjustment of quasi-fixed inputs. Therefore, the slower the adjustment process, the smaller the elasticities are in absolute value. Long-run elasticities, on the other hand, account for the full adjustment of quasi-fixed inputs, and measure the optimal *direct and indirect* response of producers to price changes. They are discussed in more detail in de Brauw, Huang, and Rozelle.

Data

Provincial-level cross-section, time-series data for 1975–95 are used in the analysis, using data from thirteen provinces in North China. Output for wheat, maize, and other grains, and cash crops (cotton, sugar cane, peanuts, and rapeseed) are measured in kilograms and after 1980 are from published statistical compendia from the State Statistical Bureau. Prior to 1980, data for these

variables come from provincial yearbooks. Data on total sown area in each province are from the same source. Cash-crop output is an aggregated variable; output values for each individual crop are summed, then divided by a Stone price index. Prices for grain, cash crops, and fertilizer are obtained from China's national "Cost of Production Survey." Prices are generated by dividing total revenues or expenditures by quantity, an operation that is consistent with Lin. The price data are from each province before 1984 and in national statistical compendia thereafter. The irrigation stock, research stock, and incentive reform variables were created using data from provincial ministries and are described in full in de Brauw, Huang, and Rozelle.

Econometric Results

To estimate the relationship among the two quasi-fixed inputs (equation (2)), three outputs (equations (4) and (5)), and one variable input (equation (3)), a nonlinear, three-stage least squares estimator is used. The estimator accounts for contemporaneously correlated error terms. The six-equation system for North China contains forty-six exogenous variables and 135 parameters. The full set of estimated coefficients for equations (1)–(4) and associated short- and long-run elasticities are reported in de Brauw, Huang, and Rozelle.

Increasing Flexibility during China's Reforms

The estimated adjustment-cost parameters R11 and R22 are relatively small in absolute value terms, highlighting the importance of accounting for dynamic adjustment costs in the analysis of China's agricultural crop area and farm-labor decisions during the incentive reform period (table 1). Statistical tests strongly reject the hypothesis of full adjustment, indicating that sown area and agricultural labor do not adjust to their long-run point of optimality in one period (see de Brauw, Huang, and Rozelle 2000).

To estimate the time of adjustment in the incentive reform period, we invert the R matrix, and we find that in the early reform period, land adjusts in about six years, and labor adjusts in three years. These figures are

Table 1. Adjustment Parameter Estimates from Nonlinear, Three-stage Least Squares Estimators for Northern China

Parameter	Estimate
R11	−0.16
	(3.65)
R22	−0.35
	(8.39)
R11D	−0.04
	(3.04)
R22D	−0.25
	(5.51)

Note: t-ratios in parentheses. The full set of parameter estimates are reported in Appendix C of de Brauw, Huang, and Rozelle.

consistent with the findings of Huang, Rosegrant, and Rozelle, which estimates adjustment times of five years for land and four years for labor for the agricultural economy as a whole during the entire post-1978 era. Hence, our results can be interpreted as indicating that frictions in the economy kept producers from fully adjusting their labor or sown area during the incentive reform period.

Interestingly, even though sown area and labor do not adjust instantaneously, during the incentive reform period China's rural economy is not particularly rigid in a comparative sense. Natural-, behavioral-, and policy-created barriers exist in every agricultural economy. In fact, when these results are compared with results of similar adjustment-cost analyses in other countries, one might conclude that China's crop sector adjusted rather quickly. With the exception of sown area adjustment for less regulated crops in North America (such as soybeans in the United States), analysts estimate that sown area can take up to fifteen years to equilibrate after exogenous shocks (because of base acreage and area quota policies), whereas labor requires six to nineteen years (reviewed in Warjiyo). Despite the existence of policy-created barriers in China, adjustment may occur faster than in North America because the relatively labor-intensive farming systems and more responsive, small-scale rural-based industrial sector, ultimately make resource reallocation among sectors less costly. Apparently, even though formal markets are not complete, informal institutional arrangements may have allowed China's farmers to engage in exchange even in the early reform period.

The model allows us to test the hypothesis that the speed of adjustment increases during the market-liberalization period in the late 1980s and early 1990s (table 1). The negative and statistically significant coefficients on the interaction terms (R11D and R22D) illustrate that quasi-fixed factors have begun to adjust even faster in the late reform period. The flexible acceleration parameters for labor and sown area are −0.60 (−0.35–0.25) and −0.20 (−0.16–0.04). In terms of the time of adjustment to the profit-maximizing point, the speed of adjustment becomes faster after market reform begins: five years for land (down from six) and one and two-thirds years for labor (down from three). If faster adjustments of land and labor by producers are made possible by better markets and fewer restrictions on producers, the liberalization reforms have increased efficiency in China's late reform economy.

Increasing Responsiveness during China's Reforms

We also produced evidence that responsiveness increased in the market-liberalization period. To show this, we reestimate the model, interacting the dummy variable with additive parameters associated with own-price responses. We then calculate elasticities based on the second set of estimated parameters. The interaction terms are all significant, at least at the 10% level, which indicates that own-price responses appear to change after market liberalization begins. Table 2 summarizes the changes in responsiveness of quasi-fixed and variable inputs to own prices (own-price elasticity changes based on estimating changes in parameters across periods). Among all inputs, responsiveness of labor appears to rise most significantly (row 2). The elasticity of sown area, however, does not change (row 1).

Somewhat unexpectedly, the own-price elasticity for fertilizer seems to show less price responsiveness (row 3). However, since the complete development of fertilizer markets did not become permanent until the 1990s (Ye and Rozelle), it is possible that we should not expect to see increased responsiveness until 1990. To test whether the fertilizer own-price elasticity becomes more responsive in the second half of the late reform period, we reestimate the model with own-price responses again, this time interacting them with a dummy variable that is 0 for all years before 1990 and 1 thereafter. The own-price fertilizer elasticities calculated with

Table 2. Changes in Responsiveness of Quasi-fixed and Variable Inputs: Own-price Elasticity Changes Based on Estimating Changes in Parameters across Periods

Own-Price Elasticity of:	1975–84	1985–95
Sown area	−0.001	−0.001
Labor	−0.013	−0.082
Fertilizer	−0.867	−0.467
Own-price elasticity of:	1975–89	1990–95
Fertilizer	−0.229	−0.446

Note: Elasticities are calculated using a modification of the model that allows for the own-price response of each output or input to change for the later period (1985–95 or 1990–95). All elasticities are calculated using parameters in Appendix C of de Brauw, Huang, and Rozelle expect for fertilizer that used a model with dummy variables indicating change in own-price responsiveness between 1975–89 and 1990–95.

these parameters are shown in table 2, row 5. Our findings based on this new model indicate that after 1990 fertilizer becomes more own-price responsive (−0.229 before, −0.446 after). With the exception of sown area, then, our results are consistent with the interpretation that the late period liberalization policies made producers more sensitive to wage and fertilizer price changes.

Conclusions

In this paper we tried to develop a framework to estimate how market-liberalization reforms affect producer behavior. Building on the adjustment-cost literature, we generate two measures of the changes in producer behavior that arise during periods of market liberalization: changes to flexibility and changes to responsiveness.

Our results find that the behavior of producers in China was affected significantly by the liberalization reforms, but the effects were fairly minor. Farmers increased their speed of adjustment between the early and late reform period for both labor and sown area. Our estimates of own-price elasticities for labor and fertilizer indicate that producers are also becoming more responsive. These moderate changes in behavior have also translated into moderate gains in the late reform period. In other work (de Brauw, Huang, and Rozelle), we estimate that the magnitude of the annual gains in efficiency from increased responsiveness and flexibility in the late reform period is substantially less in percentage terms (less than 1% per

year) than that from the incentive reforms in the early reform period (up to 7% per year). However, the effect of market liberalization does seem to be increasing slightly over time.

Based on this record, what can be said about the success or failure of China's reforms? First and unambiguously, our work is consistent with a story that gradual transition has worked—at least in the case of China and at least through the second decade of reform. The incentive reforms generated large increases in output and productivity and the market-liberalization reforms have not led to a fall in either.

Judging the effectiveness—positively or negatively—of the market-liberalization reforms, however, may be premature. It is tempting to say, on the basis of our work here and elsewhere, that the gains from market liberalization were disappointingly small. The emergence of markets has only marginally increased flexibility and responsiveness and has not led to large increases in growth of the agricultural sector. A more careful interpretation of our results may lead to other conclusions. First, our paper does not attempt to measure the gains of increased resource mobility between the agricultural sector and the rest of the economy. These effects could be quite large. Moreover, even within agriculture we do not know if we are seeing changes in efficiency due to relatively small changes in markets *or* if the market reforms are largely completed and most of the growth potential is already captured. If the former interpretation is true, the outlook for future growth may be quite optimistic. It may be that continued market liberalization will eventually lead to increasingly large increases in the performance of the agricultural economy, but that to date China's gradual shift to the market is just that: gradual. If continued market liberalization promises steady, or even increasing, output and profit growth, our paper would be consistent with calls for China's leadership to strengthen its resolve to carry through with its market reforms.

References

de Brauw, A., J. Huang, and S. Rozelle. "Increased Flexibility, Responsiveness and Efficiency from Market Liberalization Reforms in China's Agricultural Sector." Working paper,

Dept. of Agr. and Res. Econ., University of California, Davis, 2000.

Epstein, L. "Duality Theory and Functional Forms for Dynamic Factor Demands." *Rev. Econ. Stud.* 48(January 1981):81–95.

Fan, S. "Technological Change, Technical and Allocative Efficiency in Chinese Agriculture: The Case of Rice Production in China." EPTD Discussion paper, International Food Policy Research Institute, 1999.

Huang, J., M. Rosegrant, and S. Rozelle. "Public Investment, Technological Change, and Reform: A Comprehensive Accounting of Chinese Agricultural Growth." Working paper, Food Research Institute, Stanford University, 1995.

Huang, J., S. Rozelle, R. Hu, and S. Jin. "The Creation and Spread of Technology and Total Factor Productivity in China: An Analysis of the Contribution of China's Research System and CG-supplied Genetic Material." Working paper, Dept. of Agr. and Res. Econ., University of California, Davis, 2000.

Lin, J.Y. "Rural Reforms and Agricultural Growth in China." *Amer. Econ. Rev.* 82(March 1992):34–51.

Lucas, R. "Adjustment Costs and Theory of Supply," *J. Polit. Econ.* 75(August 1967):321–24.

McMillan, J. and B. Naughton, "How to Reform a Planned Economy: Lessons from China." *Oxford Rev. Econ. Policy* 8(1992):130–144.

Rozelle, S. "Gradual Reform and Institutional Development: The Keys to Success of China's Rural Reforms." *Economic Reform in China: Lessons for Economics in Transition*. Barry Naughton, ed. Chap. 7. Ann Arbor: University of Michigan Press, 1996.

Sicular, T. "Redefining State, Plan, and Market: China's Reforms in Agricultural Commerce." *China Quart.* 144(1995):1020–46.

Warjiyo, P. "Resource Adjustment, Dynamic Price Responses, and Research Impacts in the United States Agriculture, 1950–1982." PhD dissertation, Department of Agricultural Economics, Iowa State University, Ames, IA, 1991.

Wen, J.G. "Total Factor Productivity Change in China's Farming Sector: 1952–1989." *Econ. Develop. and Cultur. Change* 42(1993):1–42.

Ye, Q. and S. Rozelle. "Fertilizer Policy in China's Reforming Economy," *Can. J. Agr. Econ.* 42(July 1994):191–208.