Chapter 4

Economic Competitiveness of Sweetpotato as Animal Feed in China

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Abstract

Liberalization of agricultural trade is likely to increase China's reliance on imported feed grains, especially maize. The degree to which Chinese livestock growers switch to imported feed grains will depend largely on the competitiveness of locally-grown feeds. Sweetpotato is China's second most important feed source in pig production after maize, but has largely been ignored in previous assessments of livestock feed situation in China. This paper analyzes the economic competitiveness of sweetpotato in China using a Policy Analysis Matrix (PAM). The results show that policy distortions have penalized sweetpotato relative to maize. The extent to which sweetpotato can substitute for maize in pig feed will depend on the direction of future policies, the pace of structural change in pig production, and on technology developments affecting the two crops. If productivity growth in sweetpotato continues to lag behind that of maize and other feed crops, we can expect to see the use of sweetpotato for pig feed gradually decline, even in household backyard pig production. Increased investment in sweetpotato research and extension and removal of the current policy distortions are steps for realizing sweetpotato's potential in China's agricultural economy.

Introduction

China's accession into the World Trade Organization raises significant questions regarding future agricultural production and trade patterns. While trade liberalization is generally expected to exacerbate China's trade deficit in feed grains, the extent to which China's livestock growers will switch to imported feed will depend largely on the competitiveness of locally produced feed stuffs. Most previous analyses of feed supply and demand outlook in China have focused on cereal grains while the potential contribution of root and tuber crops, especially sweetpotato, have largely been ignored (see, for example, Simpson *et al.* 1994; Crook and Colby 1996; Tian and Chudleigh 1999). However, sweetpotato is the fourth major staple crop and the second largest feed grain in China after maize. Since the 1970s sweetpotato production in China has remained fairly stable at 20-23 million tons/year in 'grain equivalents',[1] although over the last few decades utilization of sweetpotato has changed dramatically - as food staple use declined from about 50 percent of total production in the 1970s to less than 15 percent by the 1990s, feed and industrial use increased. Huang *et al*. (2001b) estimated that by the late 1990s, half of the annual sweetpotato crop was used for pig feed, implying that sweetpotato alone supplied between 7-10 percent of China's total feed demand.[2]

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Pork accounted for nearly 80 percent of China's meat output in 1996 (Fuller, Hayes, and Smith, 1999), although pig producers in China are generally small scale relying heavily on homegrown feeds for animal production. This study is an analysis of the efficiency of substituting sweetpotato for maize as feed in pig production in China. The extent to which sweetpotato can substitute for maize as feed depends largely on whether the cost of sweetpotato-based feed is economical relative to cereal-based feed. Relative prices are likely to differ regionally within China, especially between coastal provinces and the interior. Further, policy distortions will cause divergence between social and private prices of commodities and inputs. Unlike sweetpotato, which is mainly consumed within the locality it is grown, maize is a widely traded commodity. Hence, the cost of maize is likely to be strongly influenced by trade and exchange rate policies.

We construct a Policy Analysis Matrix (PAM) of the social and private costs of maize and sweetpotato production for Shandong and Sichuan Provinces, two of the largest sweetpotato- and pig-producing areas in China. Shandong is located on China's eastern seaboard and is increasingly integrated with global markets. Sichuan, on the other hand, lies in the more isolated interior. To obtain accurate data on crop and livestock production, we conducted a survey of nearly 200 farm households from 20 villages in these provinces. This was supplemented with secondary data to construct the PAM. We assess the competitiveness of sweetpotato as pig feed under a number of alternative future scenarios.

Methodology and data

There are at least two basic ways to analyze the efficiency of sweetpotato as a substitute for maize as feed in animal production. The first is to examine the efficiency of raising animals with the two alternative feeds, sweetpotato and maize. However, most livestock farms in China actually use a mix of feeds. Even farmers who produce sweetpotato primarily for their own feed use also use substantial amounts of maize, other grains and forages in feed mixtures. Therefore, it is difficult to investigate the efficiency of sweetpotato as a substitute for maize in feeding pigs through a direct comparison of animal production practices is difficult. Another way to examine the efficiency of sweetpotato as substitute for maize feed is to look at the profitability of sweetpotato and maize production on farms where both are used as feed. In this study, we follow this second approach and develop a PAM (Monke and Pearson 1989) to analyze the effects of policies and other factors on the comparative advantages of maize and sweetpotato in pig production. That is, we analyze the relative costs and profitability of producing sweetpotato versus producing maize on one's own farm or purchasing feed from the market.

The general framework of a PAM is summarized in Table 1. The method distinguishes between private and social profitability. Private profitability (shown in the first row of the table) is determined using actual input and output prices prevailing in the domestic market. Private profitability presents the actual competitiveness of sweetpotato versus maize production under current policies and technologies. Social profitability is

estimated after removing the price-distorting effects of policies. With no policy distortions, social profitability measures the actual costs and benefits of the production system for the country or region. Social profitability, shown in the second row of Table 1, provides a measure of comparative advantage. At the margin, a positive social profit indicates that the system uses scarce resources efficiently and the commodity has a static comparative advantage. When social profits are negative, a sector cannot sustain itself without assistance or continued policy interventions from the government. A negative social profit implies that at the margin, the real cost of producing the commodity exceeds the cost of importing the commodity. Comparing social profitability of alternative uses of land and other resources provides useful information to policy makers in determining how policy changes may effect allocative efficiency in agricultural production.

Because social values are the values given under the assumption of no policy interventions and competitive markets for both inputs and outputs, exported goods (both input and output) are measured at f.o.b. (free on board) prices and import goods are at c.i.f. (costs, insurance, freight) prices. Border prices are adjusted by internal transportation costs for different regions of a country to derive local social prices for tradable goods. For non-tradable goods, social prices are measured as the return from the best alternative use.

The last row of Table 1 gives the divergences between private and social valuations of revenues, costs, and profits. These divergences are considered as the effect of distorting policies that can be a source of economic inefficiency. From the policy analysis matrix, one can derive several important indicators of efficiency and comparative advantage such as the nominal protection rate on tradable output (NPRO), the nominal protection rate on tradable input (NPRI), the effective protection rate (EPR), domestic resource cost (DRC), and social cost-benefit ratio (SBC).

The nominal protection rates (NPRO and NPRI) show the impact of commodity-specific price interventions such as price supports, government procurement and distribution, import tariffs, exports taxes, and quantitative restrictions on domestic trade. The nominal protection rate is the percentage difference between the domestic and border prices converted at the official exchange rate. In the PAM, NPRO equals the ratio of private to social revenue (A/E in Table 1) and indicates the degree of revenue transfer. NPRI equals the ratio of private to social cost of tradable inputs (B/F in Table 1) and shows the degree of transfer of tradable input costs. To measure the total effect of government interventions, including the effect of exchange rate distortions, the EPR is estimated as the ratio of value added in private prices (A minus B in Table 1) to value added in the world prices (E minus F in Table 1). EPR is the percentage difference between domestic and border prices converted at the market equilibrium exchange rate. It indicates the degree of transfer of output and tradable input as a results of price distortions.

The DRC and SCB are used to compare the relative efficiency or comparative advantage of agricultural commodities. The DRC is the ratio of social value-added to the social cost of domestic factors [G/(E-F) in Table 1]. If DRC is greater than one, it implies that a country has a comparative advantage in producing that crop. But if DRC is less than one, then it implies that a gain in efficiency can be achieved if domestic resources

were reallocated to a different activity. The DRC indicator is widely used in developing countries to measure comparative advantage and guide policy reforms. However, the DRC may be biased against activities that rely heavily on domestic non-traded factors such as agricultural land and labor. A good alternative for the DRC is the SCB, which accounts for all cost and avoids classification errors in calculation of DRC (Masters and Winter-Nelson 1995). SCB is defined as (F+G)/E in Table 1, or the ratio of total social cost of all inputs to total social revenue.

For this study, primary household data are used to assess the incentives governing crop production and the efficiency of substituting sweetpotato for maize as feed in swine production. Farm survey data were collected from a sample selected on the basis of four criteria. First, areas where sweetpotato and maize were part of the local farm production system were selected. Second, pig raising should be an important or popular activity in the area. Third, within selected villages, households were randomly selected from different income strata. Finally, the samples were drawn from villages and households varying in numbers of pigs raised to get a stratification by scale of pig production.

Based on these criteria, Sichuan and Shandong, the two largest sweetpotato-producing provinces in China, were selected as case study areas. Further, areas within the provinces where sweetpotato is primarily used as feed were selected. Although in Shandong, sweetpotato used for food processing exceeds that used for feed, we purposely selected counties where feed is the primary use of sweetpotato. Thus, the results on sweetpotato utilization and production in Shandong may not be representative of the province as a whole.

Counties selected for farm-level data collection included Jiangjin, Jiange and Leshan in Sichuan and Feixian and Zhucheng in Shandong. Two villages were selected in each country and 20 sample households were selected from each village according to the criterion described above. Interviews were conducted in 1998 to obtain information on farm household characteristics, production and consumption of major crops, and livestock production and feed use during 1997. From 200 sample households, 192 useable responses were obtained for analysis.

Two sets of prices were used to estimate budgets that were used to determine the profitability of sweetpotato versus maize as pig feed. Financial prices, which are the actual market prices paid by farmers for inputs and received for outputs, are used to determine financial, or private, profitability. Economic prices, which are shadow prices representing the scarcity value of inputs and outputs in the Chinese economy are then substituted for the financial prices to determine economic, or social, profitability.

Financial prices were collected as part of the farm survey and represent prices actually paid and received by farmers during the 1997-98 crop season. For maize, the financial prices were 1.39 Yuan/kg in Sichuan and 1.21 Yuan/kg in Shandong (Table 2). Sweetpotato prices were considerable lower at 0.92 Yuan/kg in Sichuan and 1.04 Yuan in Shandong.[3]

The divergence of the market prices from the economic or social prices is associated with domestic price and marketing policies as well as other policies that have

impact on the sector performance. Price and market reforms are key components of China's development policy shift from a socialist to a market-oriented economy. The price and market reforms initiated in the late 1970's were aimed at raising farm level prices, gradually liberalizing the market. These reforms included increases in government procurement quota prices, reduction in the quota levels, introduction of above-quota bonuses, negotiated procurement of surplus production of grains, oils, and most other commodities, and flexibility in private marketing of surplus agricultural production. Sweetpotato is one of the first crops within the agricultural sector that was liberalized in the early 1980s when the government procurement quota was phased out. Since then, its price has been determined by local demand and supply.

Price and marketing reform for cereal grains lagged far behind that of other agricultural commodities. Despite substantial efforts to liberalize the price and market structure of the agricultural sector, grains continue to be heavily affected by commodity-specific policies. Through procurement polices, farmers received prices below the competitive market prices at least until after 1998 (Huang and Chen 1999). These price distortions depressed agricultural production and redistributed income from farmers to urban consumers and the agro-processing sector.

In this study, the financial price for maize is the weighted average price received by farmers from government procurement and the local market. Because sweetpotato is not under government procurement, the financial price for sweetpotato is the price that the farmer should pay for sweetpotato for feed use in the local market.

To calculate economic (social) prices requires not only consideration of domestic pricing policies, taxes, and barriers to trade, but also exchange rate policies. Exchange rate distortions can have a considerable effect on the divergence between private and social prices of tradable goods. Historically, China maintained an overvalued currency, which discriminated against domestic agricultural producers. However, exchange rate policy has undergone substantial reform. Between 1978 and 1994, the real exchange rate depreciated more than 400 percent. Since 1994, however, the nominal exchange rate has been kept about constant and there is a growing consensus among analysts that China's currency has again become overvalued (Yin and Stoever 1994; Huang and Chen 1999). In this study, we assume that the 1994 unified exchange rate was at the time a shadow nominal exchange rate, with relative purchase power parity holding between China and the United States. For 1997, we calculate the shadow nominal exchange rate as the exchange rate consistent with relative purchase power parity holding for the period of 1996-97. The estimated shadow nominal exchange rate for 1997 is 11.18 RMB/US$, while the official exchange rate is 8.29 RMB/US$.

With all of these considerations, social prices for maize were 1.46 Yuan/kg in Sichuan and 1.35 Yuan/kg in Shandong.[4] These are about 5 percent higher than the private price of maize in Sichuan and 12 percent higher than the private price in Shandong. Social prices of sweetpotato are found by adjusting private prices by the exchange rate distortion. Thus, the social price of sweetpotato is about 10 percent higher than the private price.

Social prices of inputs are also required for the PAM. Since China is a net

importer of seed, chemical fertilizer, plastic materials, and pesticides, the social prices for these inputs are the respective import prices adjusted by exchange rate distortions and transportation costs to the farm gate. For non-tradable inputs like land and labor, prices are measured at the highest return offered by alternative uses. The social opportunity cost of labor is assumed to be the local wage rate for off-farm employment. For some households, however, the opportunity cost of time may be less than local off-farm wages, especially if farm labor is supplied by other family members or during hours when off-farm jobs are not available. Since labor is the most costly input in both sweetpotato and maize production, PAM results are sensitive to assumptions on wages. The price of land includes agricultural taxes (usually paid in kind based on the area of land leased to the household) but does not include land rental rates because of the lack of data on land rents in the farm survey. Private and social prices used in the study are given in Table 2.

To derive the PAM indicators, we decompose both total private and total social costs into domestic and tradable components. Tradable goods are those that can be imported or exported. Examples include maize output and production inputs such as seed, fertilizer, tractors, and irrigation pumps. Assumptions on the share of tradable and non-tradable component of each input and output are given in Table 2. This involves calculating the appropriate import or export parity price. In a few cases where parity prices are difficult to compute because no clear trading pattern is evident, the domestic market-clearing price is used, with appropriate adjustments for significant distortions attributable to government policies (e.g. price controls, taxes, subsidies, and exchange rate distortions). It is worth noting that sweetpotato is rarely traded in the world market.[5] In our study sites sweetpotato was primarily fed to animals also raised on the farm and not marketed. In this study, we therefore use two alternative assumptions for the proportion of sweetpotato that is tradable: zero and 10 percent.

In the sensitivity analysis, various alternatives are made in the prices of inputs and outputs, tradability of sweetpotato, productivity enhancements, and exchange rate adjustments to explore the likely effects of policy changes on the efficiency and comparative advantage of producing the two major feed crops, sweetpotato and maize.

Some survey results: feed utilization, livestock structure, and crop production

Among the 192 households interviewed from our farm sample, 146 households (76 percent) raised pigs. Farmers used various feeds in pig production, including sweetpotato, maize, other grains (for example, low quality indica rice in Sichuan), various meals, and roughages (including sweetpotato tops). Compound feed was a recent introduction in these communities and amount of use was still very small. Table 3 provides a breakdown of the feeds used in the farm sample. In the sample, sweetpotato roots provided 20 percent of total grain feed in Sichuan and 34 percent of total feed in Shandong. Sweetpotato tops were also the single most important source of fodder for pig diets in both locations.

As is typical in China, the great majority of pig-raising households engage in backyard production, raising just a few animals a year mainly on locally grown crops and household wastes. Of the 192 households in the sample, only five raised more than 10

pigs a year.

Farm production of sweetpotato was positively correlated with the number of pigs raised, but only up to three pigs (Table 4). Further increase in the number of pigs was not associated with a further rise in sweetpotato production. Sweetpotato production declined slightly in households raising more than three pigs. Several factors may explain the linkage between pig and sweetpotato production. Home produced sweetpotato is a traditional and cheap source of feed for household backyard pig production, particularly where the rural feed market is not developed and therefore commercial feed is not available locally or too expensive for credit-constrained households. Increases in backyard pig production are therefore positively correlated with household sweetpotato production when the number of pigs is small. However, the potential to increase livestock production through the use of homegrown feed is limited by farm size. Each household in our sample only had access to about 0.4 hectares, which the household had to use not only produce feed, but also to produce vegetables and other food crops for both home consumption and government procurement requirements. Further expansion of sweetpotato production may also be limited by the availability of family labor, since sweetpotato is much more labor intensive than other grain crops. Therefore, increasing the number of pigs raised above three appears to require the use of alternative feed grains or commercial feed.

The above discussion implies that an important factor determining the use of sweetpotato for feed is the pace of structural change in animal production. In 1996 backyard pig production accounted for about 81 percent of total pig production in China, but this share was declining by about 1 percent per year (Table 5). A recent study by Chen (2001) shows that several factors account for the intensification of pig production (at the expense of backyard pig raising), particularly labor market development and migration, farm income growth, and various risks associated with farm production. However, the trends in backyard pig production vary widely across provinces. The proportion of households raising pigs has been falling most rapidly in coastal provinces but remains high in some interior provinces like Sichuan and Hunan (Zhang 1998).

The farm survey provided the basis for deriving private profitability and competitiveness of maize and sweetpotato in the study areas. Table 6 summarizes the inputs and output of sweetpotato and maize production among sample households. For both crops, labor and manure inputs are much higher in Sichuan than in Shandong. The need to incorporate the high doses of farmyard manure into the soil largely explains the higher labor input. On average, farmers spent more than 400 days/ha for sweetpotato and maize production in Sichuan, compared with 257 days/ha for sweetpotato and 155 days/ha for maize in Shandong Sweetpotato yield in Shandong (5289 kg/ha) was higher than in Sichuan (4665 kg/ha) due to better land and growing conditions for sweetpotato. In Sichuan, sweetpotato is mainly planted on hillsides and mountain slopes while in Shandong, sweetpotato cropland is usually flat with better quality soil. Moreover, sweetpotato has a longer growing period in Shandong than in Sichuan.

Financial (private) profitability shows that farmers in Sichuan province earned negative profits in 1997 from sweetpotato and maize when family labor was priced at the prevailing off-farm wage rate (Table 7). However, with relatively fewer opportunities for

off-farm employment in Sichuan and substantial migration out of rural areas, the opportunity cost of household farm labor may be substantially below off-farm wage. Rural Sichuan had seen millions of men migrate to cities and other provinces in search of work, leaving much of the farming activity to women, the young and elderly (Rozelle *et al.* 1999). If family farm labor in Sichuan was valued at only 65 percent of the observed off-farm wage, sweetpotato would have achieved break-even profit and maize would have earned a profit of 776 Yuan/ha. In the coastal province of Shandong, by contrast, there has been more industrialization and opportunities for off-farm work are greater. Here, the off-farm wage rate may be a truer reflection of farm labor opportunity cost. At this wage, both sweetpotato and maize had positive financial profit.

The farm budgets represented in Table 7 suggest that farmers on average earned less from sweetpotato than maize. In Shandong, the private profitability of sweetpotato was about 20 percent less than that of maize. In Sichuan, even considering a lower opportunity cost of farm labor, sweetpotato earned only a fraction of the returns from maize.

Farmers in Sichuan may be willing to accept lower returns from sweetpotato for a number of reasons. One, sweetpotato is widely planted on hillsides and helps control soil erosion, while maize is preferred on bottom lands. Second, both sweetpotato roots and tops are used for animal feed and consumed by the household. However, the results suggest that as labor costs rise, sweetpotato production is likely to become increasing unprofitable. To keep sweetpotato production attractive under the current policy environment in China will require improved technology to increase yield, save labor, and expand utilization.

Results of the Policy Analysis Matrix

The effect of policies on the relative profitability of sweetpotato and maize is shown by the completed Policy Analysis Matrix (Table 8). A negative divergence between private and social profit implies that the net effect of policy intervention is to reduce profitability of crop production.

The divergences of private and social profits in both Sichuan and Shandong indicate that sweetpotato profitability would improve substantially if all policy interventions were removed. In Shandong, profit from sweetpotato would increase from 790 Yuan/ha to 1,350 Yuan/ha, or by 70 percent. In Sichuan, sweetpotato profitability would improve by about 30 percent, although it is still negative when using off-farm wage to price farm labor.

For maize, a removal of policy distortions would reduce profitability in Sichuan but increase profitability in Shandong. This mixed result can be explained by the stronger price effect of policy interventions in Shandong. The divergence between private and social revenues from maize was about 11 percent in Shandong but only 5 percent in Sichuan. This difference reflects Shandong's greater access to international markets and lower farm-to-market transportation costs compared with Sichuan.

A comparison of the relative profitability of sweetpotato and maize within each province indicates that policy distortions do not favor sweetpotato. In Sichuan, removing policy interventions would improve sweetpotato profitability 24 percent while reducing maize profitability by 83 percent. In fact, removing policy distortions completely eliminates the profit advantage of maize in Sichuan. In Shandong, removing distortions improves profit from sweetpotato by 70 percent while improving maize profits by 12 percent. Rather than earning less profit from sweetpotato compared with maize, Shandong farmers would earn more profit from sweetpotato than maize if policies distortions were eliminated.

Several policy indicators on protection rates and domestic resource costs in the production of the two crops are given in Table 9. The nominal protection rate of output (NPRO) shows that the policies taxed production of both sweetpotato and maize, but the extent of taxation was higher for sweetpotato. The distortion lowered sweetpotato domestic price to only 84 percent of world price in Sichuan and 86 percent of world price in Shandong. Policies also decreased the producer price of maize below the world price by 5 percent in Sichuan and 10 percent in Shandong. The price distortions arose mainly from the overvaluation of the domestic currency. Indeed, at the official exchange rate NPRO is 1.01 for sweetpotato in both Sichuan and Shandong. For maize, this was 1.26 in Sichuan and 1.19 in Shandong. These figures imply that the net effect of all domestic policies (excluding exchange rate policy) on crop prices was neutral for sweetpotato but protected maize by raising the domestic price of maize by 19-26 percent over the world price. All estimated values for NPRI are about 0.90, indicating that the policies reduced input costs for both sweetpotato and maize by about 10 percent. Again, the major distortion is due to the exchange rate policy.

The values of the ERP show that there is a large transfer from sweetpotato producers as a result of policy distortions. Sweetpotato is effectively taxed by 18 percent of its social value added in both Sichuan and Shandong. Maize in Sichuan faces almost no distortion in value added but faces an 11 percent reduction on social value added in Shandong. Thus, it is likely that sweetpotato would gain more than maize in value added if all distortionary policies were phased out.

The estimated values of DRC and SCB in Table 9 show that sweetpotato and maize each have an equally strong comparative advantage in Shandong.[6] The social cost of domestic factors of production accounted for only 65 percent of the value added of maize production and 71 percent of the value added of sweetpotato production. However, neither crop appears to have a comparative advantage in Sichuan given the assumptions of labor costs in this province. The values of DRC for sweetpotato and maize in Sichuan are 1.26 and 1.27, respectively, pointing out the challenges in both, sweetpotato and maize production in the face of trade liberalization and rising labor costs in this province. The fact that the values of DRC for sweetpotato and maize are similar to each other within each province implies that policy liberalization would be unlikely to lead to much crop substitution within these provinces. That is, there would be little gain in resource allocation efficiency of a province grows more of one crop than the other. The estimates of the social cost-benefit ratio (SCB) lead to the same conclusion.

In order to test the sensitivity of the results of the PAM analysis, the policy

indicators were re-estimated using alternative assumptions on key parameters. The alternative assumptions deal with the major driving factors that have impacts on social profit and DRC: crop yield, tradability of sweetpotato products, opportunity cost of family labor, and the shadow exchange rate. These results are summarized in Table 10. For convenience, we present the results shown in Tables 8 and 9 as baseline, and re-report profits, DRC and SCB (Table 10).

Given the lower sweetpotato yield in Sichuan than in Shandong, the first sensitivity analysis was made with the assumption that sweetpotato yield would increase by 20 percent in Sichuan and 10 percent in Shandong with the adoption of improved technology, while holding input levels constant. Technological improvement in sweetpotato in China has been relatively slow compared with cereal crops, but some new production innovations have begun to show significant impact in the late 1990s (Fuglie *et al*. 1999). This assumption alters social profit of sweetpotato production from (-)1023 Yuan/ha to 19 Yuan/ha in Sichuan. In Shandong, the increase in social profit is almost 50 percent. The DRC of sweetpotato declines from 1.26 to 0.99 in Sichuan. Although this value of DRC is still higher than DRC of maize in the province, it is already less than one – a turning point for sweetpotato to have a comparative advantage in a crop production. This points out the importance of research and technology investment in sweetpotato to increase productivity and improve the economic prospects for this crop.

Changing sweetpotato from a fully tradable commodity to a less tradable commodity would make the crop less competitive. While the private profit stays the same at the baseline, social profit declines, and the values for DRC and SCB rise.

Under the baseline, social opportunity cost of labor is 10 percent higher than private value. That is, the best alternative use of family labor is paid 10 percent higher than the actual observed wage in crop production. Equalizing private and social values of family labor, which in effect reduced labor costs, increases the crop's social profit and lowers domestic resource cost. The impacts are similar for both crops. However, even at this lower wage both sweetpotato and maize still show a negative social profit in Sichuan.

The last alternative examined is the assumption of overvaluation of domestic currency. In using the current official exchange rate to represent the true value of domestic currency, both sweetpotato and maize become less competitive since social prices of crops are lower – and closer to current domestic prices.

In sum, the results of the PAM show that price and trade policy interventions have been more unfavorable to sweetpotato production than to maize production in major sweetpotato-producing regions of China. While the financial (private) profitability of maize appears to be greater than sweetpotato in both Sichuan and Shandong, the social profitability of the two crops are about equal within each province. The use of sweetpotato as pig feed is a common practice throughout much of China. The extent to which sweetpotato can substitute for maize as feed in pig production will depend on the direction of future policy intervention, the rate of technology development in sweetpotato and maize, and the pace of structural change in animal production. If the growth in sweetpotato productivity is less than that of feed cereals, then cereal grains will

likely gradually substitute sweetpotato in backyard livestock production. A similar trend may result if policies continue to discriminate against sweetpotato producers. Therefore, to improve the contribution of sweetpotato in meeting China's growing need for animal feed will require increased investment in sweetpotato research and extension, and removing the current policy distortions that discriminate against the crop.

Conclusions and implications

A rapid rise in the demand for animal feed in China is expected in the coming decades in order to meet the growing consumption of animal products. Since China is less competitive than the world's major maize exporters, a growing portion of feed in China may be met through imports. While feed use of sweetpotato (the second largest feed crop in China) has increased significantly in the past two decades, previous assessments of China's feed situation have largely ignored this crop. In this study, we examined the economic incentives farmers face for growing sweetpotato instead of maize for use as feed in pig production. The results show that agricultural policies in China have tended to disfavor sweetpotato. Without policy changes or productivity improvements it will be difficult to increase the contribution of sweetpotato in meeting China's growing demand for animal feed. In fact, in the absence of new developments the use of sweetpotato as feed may gradually decline over time.

The Policy Analysis Matrix reveals the extent to which policies have been biased against sweetpotato producers. In particular, an overvaluation of the Chinese currency has resulted in a large divergence between the private and social profitability of sweetpotato production. While protective tariffs on maize have partly offset negative terms-of-trade effects arising from exchange rate distortions, sweetpotato farmers have enjoyed no such advantage. These policy distortions have penalized sweetpotato production. Estimates of the effective protection rate suggest that sweetpotato would gain more in value-added than maize if all distortionary policies were removed.

Significant regional differences in the economic incentives for using sweetpotato in animal production are also apparent. The domestic resource cost of producing sweetpotato was positive in the coastal province of Shandong but negative in the interior province of Sichuan, due mainly to higher yields obtained in Shandong and high labor inputs in Sichuan. Within each province, however, the domestic resource cost (in the absence of price distortions) of sweetpotato and maize production were similar.

Current trends augur the decline over time of incentives to farmers for producing sweetpotato and using it as feed is likely to decline in the absence of new developments. As the opportunity cost of rural labor rises with China's economic development, production of sweetpotato using current labor-intensive methods will become increasingly uneconomical. Further, as the scale of pig production increases, animal growers are likely to use less farm-grown sweetpotato and more of manufactured and cereal-based feed. Finally, trade liberalization will likely reduce the cost of imported cereal grains for animal production, lowering crop prices and the profitability of growing feed locally. Millions of sweetpotato producers and backyard pig growers, who are often poor and lacking capital to purchase commercial feed, may find themselves even more

disadvantaged. Policy reform, plus greater investment in sweetpotato research and extension for production and feed utilization, would help offset these trends.

End Notes

[1] China' agricultural statistics define "grain" to include rice, wheat, maize, soybean, sweetpotato, potato, sorghum, barley and millet. Roots and tubers are converted into "grain equivalents" by their dividing fresh weight by 5. In this study we also report sweetpotato production and price using this conversion factor in order to make the reported figures more comparable to cereal grains.

[2] Based on revised estimates of livestock numbers in China, total feed demand was estimated by Fuller, Hayes, and Smith (1999) at between 112-147 million tons in 1996.

[3] Sweetpotato prices are reported here and elsewhere in the paper in grain equivalents (fresh weight price multiplied by 5).

[4] In this study, we consider maize as an imported commodity and measure its social price at c.i.f. price plus domestic transportation costs. China has been both an importer and exporter of maize. Domestic prices have been consistently higher than border prices (protected by a tariff on imported maize) and therefore imports would generally be expected to occur. Nevertheless, since the mid 1980s China has periodically exported maize, often with the help of export subsidies. In 2000, the export subsidy on maize reached as high as 400 Yuan/ton.

[5] Processed sweetpotato products such as sweetpotato starch and noodles are tradable, but the traded quantity is thought to be small.

[6] The estimates of DRC for maize in our sample households in Sichuan and Shandong are lower than estimated by Fang and Belghin (1999), and Huang, Ma and Xu (2001) but close to those estimated by Zhang and Xu (2001).

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Table 1. General framework of a Policy Analysis Matrix

	Revenues	Costs		Profits
		Tradable inputs	Domestic Factors	
Private values	A	B	C	D
Social values	E	F	G	H
Divergences	I	J	K	L
Private profits D=A-(B+C); Social profits H=E-(F+G) ; Output transfers I=A-E. Tradable input transfers J=B-F; Domestic factor transfers K=C-G. Net transfers L=D-H=I-(J+K).				

Source: Monke and Pearson, (1989)

Table 2.Assumptions about private and social prices and tradability of inputs and outputs used in Policy Analysis Matrix

	----------Sichuan----------			----------Shandong----------		
	Private price (Yuan/kg)	Social price (Yuan/kg)	Tradable share (%)	Private price (Yuan/kg)	Social price (Yuan/kg)	Tradable share (%)
			Sweetpotato			
Sweetpotato	0.92	1.12	100	1.04	1.23	100
By-product	1.00[a]	1.00[a]	0	1.00[a]	1.00[a]	0
Capital inputs:			73			91
Seed	1.00[a]	1.08	100	1.00[a]	1.05	100
Fertilizer	4.68	5.26	100	7.26	7.90	100
Manure	0.12	0.12	0	0.12	0.12	0
Pesticide	18.18	20.43	100	24.00	26.53	100
Plastic	8.93	10.48	100	9.44	10.79	100
Tax & depreciation	1.00[a]	1.17	20	1.00[a]	1.17	20
Other cash costs	1.00[a]	1.02	50	1.00[a]	1.02	50
Labor	9.41	10.35	0	10.77	11.84	0
			Maize			
Maize	1.39	1.46	100	1.21	1.35	100
By-product	1.00[a]	1.00[a]	0	1.00[a]	1.00[a]	0
Capital inputs:			87			87
Seed	1.00[a]	1.08	100	1.00[a]	1.05	100
Fertilizer	4.82	5.42	100	5.25	5.71	100
Manure	0.12	0.12	0	0.12	0.12	0
Pesticide	41.17	46.26	100	27.00	29.85	100
Plastic	8.92	10.46	100	9.40	10.74	100
Tax & depreciation	1.00[a]	1.17	20	1.00[a]	1.17	20
Other cash costs	1.00[a]	1.02	50	1.00[a]	1.02	50
Labor	9.39	10.33	0	10.77	11.85	0

[a] Prices of by-products are normalized at 1. Tradable shares for all capital inputs are weighted average based on amount of input used and private price. They are marginally lower (1-2 percent) than those at social prices. Shadow exchange rate is 11.28 Yuan/US$, which is 34.86 percent higher than the official exchange rate (8.29 Yuan/US$).

Table 3. Shares of various feeds used in pig production

	Sichuan (%)	Shandong (%)
Grain and other feeds		
Sweetpotato	20	34
Maize	25	37
Other grains	38	8
Various meals	1	9
Compounds	8	11
Others	8	1
Total grain and other feed	100	100
Fodder		
Sweetpotato vines	38	68
Non-sweetpotato stalks	1	5
Other fodders	61	27
Total fodder	100	100

Sources: Authors' survey

Table 4. Swine and sweetpotato production of farms included in the 1997 survey

Number of pigs on farm	Number of households in survey	Total number of pigs	Pigs per household	Sweetpotato production (kg)	Sweetpotato used as feed per pig (kg/pig)
0	46	0	0.00	51	n.a.
1	47	48	1.01	188	158
2-3	46	112	2.42	253	90
> 3	53	274	5.16	206	34

Note: Number of pigs on the farm is the average number at the beginning and ending of the year. Sweetpotato production is measured in "grain equivalents" (fresh weight divided by 5).
Source: Authors' survey.

Table 5. Share of pig production by different sizes of farms(%)

	Backyard	Specialized household	Intensive
1985	94.6	2.9	2.5
1993	88.3	8.2	3.5
1996	80.7	14.6	4.7

Source: Zhang and Somwaru (2001).

Table 6. Inputs and output for sweetpotato and maize production per hectare

		Sichuan				Shandong		
		Average	Jiangjin	Jiange	Leshan	Average	Feixian	Zhucheng
				Sweetpotato				
Output	kg/ha	4665	5136	3344	5154	5289	5662	4151
Input:								
Fertilizer	kg/ha	285	322	289	229	204	220	152
Manure	kg/ha	2455	1935	1067	5041	375	422	225
Pesticide	kg/ha	0	1	0	0	3	2	4
Plastic	kg/ha	6	7	3	7	9	10	8
Labor	day/ha	420	458	305	526	257	274	201
				Maize				
Output	kg/ha	5133	5843	5064	3163	4327	4897	4069
Input:								
Fertilizer	kg/ha	614	612	716	272	284	289	280
Manure	kg/ha	1970	2320	868	4571	51	70	35
Pesticide	kg/ha	6	6	3	19	3	3	4
Plastic	kg/ha	13	8	20	0	0	0	0
Labor	day/ha	406	483	351	333	155	180	135

Notes: Sweetpotato production is measured in "grain equivalents" (fresh weight divided by 5).
Data are from authors' survey.

Table 7. Farm costs and returns of sweetpotato and maize from household survey, 1997

	Sichuan		Shandong	
	Sweetpotato	Maize	Sweetpotato	Maize
I. Total revenue (Yuan/ha)	4967	7565	6176	5668
Main product	4292	7115	5501	5218
By-product	675	450	675	450
II. Non-labor (Yuan/ha)	2358	4310	2619	2999
Seed cost	251	355	710	248
Fertilizer	1335	2959	1481	2024
Manure	300	241	46	6
Pesticide	4	247	66	81
Plastic	54	116	85	0
Other costs	8	2	3	277
Various taxes	407	390	228	298
III. Labor cost (Yuan/ha)	3951	3814	2767	1670
IV. Total cost (Yuan/ha)	6309	8124	5386	4669
V. Net return (Yuan/ha)	-1342	-559	789	1000
VI. Return to labor (Yuan/ha)	2609	3255	3556	2670
Break-even value				
Wage (Yuan/day)	6.21	8.02	13.85	17.22
Output price (Yuan/kg)	1.21	1.49	0.89	0.98
Yield (kg/ha)	6124	5537	4530	3445
Observed values				
Wage (Yuan/day)	9.40	9.40	10.78	10.78
Output price (Yuan/kg)	0.92	1.39	1.04	1.21
Yield (kg/ha)	4665	5133	5289	4327

Sweetpotato production and price given in "grain equivalents" (fresh weight divided by 5).
Source: Authors' survey.

Table 8. Results of Policy Analysis Matrix for sweetpotato and maize production

	Revenues (Yuan/ha)	Costs (Yuan/ha)		Profits (Yuan/ha)
		Tradable inputs	Domestic factors	
Sweetpotato				
Sichuan				
Private values	4967	1729	4580	-1342
Social values	5884	1932	4975	-1023
Divergences	-917	-203	-395	-320
Shandong				
Private values	6176	2389	2997	790
Social values	7203	2579	3274	1350
Divergences	-1027	-190	-277	-561
Maize				
Sichuan				
Private values	7565	3756	4368	-559
Social values	7934	4208	4749	-1023
Divergences	-369	-452	-381	464
Shandong				
Private values	5668	2615	2053	1000
Social values	6291	2872	2220	1199
Divergences	-623	-257	-167	-199

Table 9. Policy intervention indicators derived for sweetpotato and maize production

	NPRO[1]	NPRI[2]	EPR[3]	DRC[4]	SCB[5]
Sweetpotato					
Sichuan	0.84	0.90	0.82	1.26	1.17
Shandong	0.86	0.93	0.82	0.71	0.81
Maize					
Sichuan	0.95	0.89	1.02	1.27	1.13
Shandong	0.90	0.91	0.89	0.65	0.81

[1]NPRO is the nominal protection rate on tradable output.
[2]NPRI is the nominal protection rate on tradable input.
[3]EPR is the effective protection rate.
[4]DRC is the domestic resource cost.
[5]SCB is the social cost-benefit ratio.

Table 10. Sensitive analyses of Policy Analysis Matrix of sweetpotato and maize production

	Private profit (Yuan/ha)	Social profit (Yuan/ha)	DRC[1]	SCB[2]
		Baseline		
Sweetpotato				
Sichuan	-1342	-1023	1.26	1.17
Shandong	790	1350	0.71	0.81
Maize				
Sichuan	-559	-1023	1.27	1.13
Shandong	1000	1199	0.65	0.81
		Sweetpotato yield increases by 20% in Sichuan and 10% in Shandong		
Sweetpotato				
Sichuan	-484	19	1.00	1.00
Shandong	1340	2003	0.62	0.74
		Labor costs: private = social wage		
Sweetpotato				
Sichuan	-1342	-628	1.16	1.11
Shandong	790	1627	0.65	0.77
Maize				
Sichuan	-559	-641	1.17	1.08
Shandong	1000	1366	0.60	0.78
		Sweetpotato tradability: 10% only		
Sweetpotato				
Sichuan	-1342	-1848	1.59	1.37
Shandong	790	426	0.88	0.93
		Foreign exchange: shadow rate = official rate		
Sweetpotato				
Sichuan	-1342	-1807	1.60	1.41
Shandong	790	330	0.91	0.94
Maize				
Sichuan	-559	-1870	1.65	1.31
Shandong	1000	431	0.84	0.91

[1]DRC is domestic resource cost.
[2]SCB is social cost-benefit ratio.