Precision Agriculture Adoption Policy: 
Evaluation of Potential Impacts on World Cotton Markets

Jaime Malaga¹, Suwen Pan², and Raghu Kulkarni³

¹Texas Tech University, Lubbock, Texas, USA. jaime.malaga@ttu.edu 
²Texas Tech University, Lubbock, Texas, USA 
³HSBC Bank, Chicago, Illinois, USA

Abstract

World cotton trade is being affected by variables like recent expansion of new production areas, prices of alternative crops, and the impact of WTO rulings on the use of agricultural subsidies. Moreover, a potential new WTO agreement following the current Doha Round negotiations may imply drastic reductions on the level of current domestic support to cotton production. Another variable with potential implications on world trade markets is the likely adoption of a new generation of production technologies. This article explores the potential effects on world cotton markets of “precision agriculture” technologies using a partial equilibrium world model under alternative policy scenarios.

Keywords: Precision Agriculture, Cotton, Trade Policy

Politique d'adoption de l'agriculture de précision: 
une évaluation des impacts sur le marché du coton

Résumé

Le commerce mondial du coton est influencé par divers facteurs tels que la récente extension des surfaces de production, les prix des cultures concurrentes et les règles de l'OMC relatives aux subventions agricoles. Pour ce dernier facteur, des réductions drastiques du soutien intérieur peuvent découler des négociations actuelles du Cycle de Doha. Un autre facteur est l'adoption probable d'une nouvelle génération de technologies nouvelles. Cet article explore les impacts potentiels des technologies d'agriculture de précision sur le marché mondial de coton, en utilisant un modèle mondial d'équilibre partiel, sous l'hypothèse de différents scenarii de politique cotonnière.

Mots clés : Agriculture de précision, coton, commerce mondial, politique
1. Background

The U.S. cotton industry accounts for more than $25 billion in gross revenues annually and generates over 400,000 domestic jobs from the farm to the textile mill sectors. The world market share of U.S. cotton exports rose from 25% in 1990 to 37% in 2004 (ERS-USDA, 2006). Domestic support for cotton production has shielded farmers from fluctuations of prices in the global cotton market, but given the current direction of the WTO negotiations, subsidies could be greatly reduced or eliminated (WTO, 2006). The topic has received considerable attention in many countries concerned—about the U.S. cotton domestic support system. This came into the foray in the WTO rounds held at Cancun on September 2003, when a group of cotton exporting nations, led by Brazil, opposed the U.S. domestic agricultural subsidies. If the WTO Doha Round leads to a new WTO agreement it is quite likely that the new disciplines would include a drastic reduction of agricultural subsidies in all countries, including the U.S. The U.S cotton trade scenario, in the absence of domestic support, has been of research interest in the recent past (Pan et al., 2006).

Another variable of interest which has the potential to impact cotton trade flows is innovation in production technology. Improvements in agricultural production technology (both yield improvement and/or cost reduction) may have important impacts on cotton trade patterns. One such agricultural production research areas has been Precision Agriculture (PA) which is spatial information technology applied to agriculture. Also known as site-specific farming, it encompasses collecting and analyzing data for different locations within a field in a way that allows management decisions to vary in those diverse locations (Thrikawala, 1998).

The Southern High Plains of Texas (SHPT) is a semi-arid region located in the northwestern portion of Texas. It encompasses approximately 22 million acres in 42 counties. Cotton is the most important crop produced in the area in terms of both acreage and crop value. Annual cotton plantings vary between 2.6 and 3.3 million acres in a 25-county region within the SHPT, with approximately 50 percent of these acres being irrigated (Yu et al., 1999). Yu (2000) analyzed irrigated cotton production under PA practices in the SHPT. The data for the study came from Agricultural Complex for Advanced Research Extension Systems (AG-ACRES). Optimal spatial Nitrogen (N) application levels and net revenues above N were derived. This was done by equating marginal physical product of N to the ratio of input to output price to obtain maximum profit at each location. Results indicated that when compared to PA practices, Nitrogen (N) was over applied on 45.83% of the field at an average of 26.67 pounds per acre under conventional methods and as a consequence profits and environment both suffered.

Lambert and Lowenberg-Deboer (2000) have pointed out that it is difficult to measure the economic benefits of Precision Agriculture (PA). The most common ways to evaluate the impacts have been to compare conventional yield levels (Bronson et al., 2003, Yu, 2000, and Yu et al., 1999), potential environmental benefits (Whitley et al., 2000, and Schumacher et al., 2000), and profit levels to PA techniques. Profitability has been and remains the driving force for further research. However PA profitability has been inconsistent. Lowenberg-DeBoer and Swinton (1997) conducted a review of the economics of precision agriculture, finding that economic feasibility has been found to be dependent upon several factors including many components of the underlying economic, agronomic and engineering environment. One way to show the economic feasibility has been to compare the change in the allocation of production inputs (Nitrogen, Phosphorous, Lime) from conventional to PA practices and how they affect the yield and profits. Thrikawala et al. (1998), and Yu et al., (1999) (for Nitrogen input) and Bongiovanni and Lowenberg-DeBoer, (2000) (for lime input) used optimization models to check the change in the allocation pattern and quantity levels of the inputs. These studies found that PA practices result in higher profit levels with optimized usage of inputs and higher yields. Segarra et al. (1989) examined the dynamic relationship between input residual
and cotton yield on the SHPT to derive N fertilizer optimal decision rules for irrigated cotton. The study showed that input nitrogen largely influences optimal nitrogen application decision rules in the SHPT. The major highlight of the study was the incorporation of the time dimension in the dynamic model and how this factor affects production control if a long run analysis was to be considered. Bronson et al. (2003) conducted experiments at Lamesa and Ropesville, Texas, during the years 2000 and 2001, to determine the effect of landscape position on Phosphorus (P) accumulation, and P fertilizer response under PA practices. They found that, landscape position and slope had significant impacts on cotton yields in both years, but not on P fertilizer response. They also suggested that P response might be more predictable with variable-rate fertilization, which matches soil test P and P fertilizer rate on a site-specific basis. They also found that behavior of Variable Rate Technology (VRT) for P to be inconsistent, and suggested that more research to determine if fertilizer savings would be consistent and widespread enough to offset the additional costs associated with intensive soil sampling, analysis and the specialized equipment that variable-rate fertilization requires.

The objective of the current research was to evaluate the U.S cotton trade effects as a function of increased agricultural productivity due to new technologies under two alternative scenarios (current support programs and free trade). If precision farming does lead to higher productivity in cotton production, what would be the net impact of the new technology adoption on farmers based on the global cotton trade scenario? What if all producers adopt these technological changes? All in all, the emphasis of the current research is the study of the relationship between technology related production research and cotton trade and its eventual impact on world and domestic prices, and quantity traded.

There are several literatures available for the effect of technology (precision agriculture practices) on cotton yield and producing cost. Finck (1988) suggested that it can increase yield around 9%; Yu (2000), Kulkarni (2006), and Velandia (2007) found the effect on cotton yield is between 2.3-5% through yield monitoring and mapping. They also suggested the effects on profit would be less than 2%. Based on those results, we analyzed the effects of precision agriculture practices on cotton trade based on the following assumptions: (1) PA practices lead to a 5% increase in yield levels, (2) PA practices lead to a 3% reduction in total costs and (3) All farmers in the U.S adopt these practices. The world cotton model is simulated for the years 2007-2011, subject to a combination of the above three assumptions. The simulation is done under two scenarios as suggested in the conceptual framework, (1) no subsidies scenario, and under (2) current support programs.

The analysis is presented in four sections. The first section provides the theoretical framework linking agricultural production advances due to technology and trade flows. The second section introduces the methods and procedures including a brief description of the partial equilibrium model used to quantify the trade parameters discussed in the conceptual framework. Section three and four present the simulation results and a discussion of the findings, respectively.

2. Conceptual framework

The intention of this section is to apply a partial equilibrium theoretical framework to derive the directional changes in world price and quantity traded due to production technological advances under free trade and domestic support program scenarios. The relationship between agricultural technology advances and impact on trade flows rely on the hypothesis that precision farming practices, compared to conventional farming, result in either higher yield and/or reduced costs and thereby result in initially higher risk adjusted returns.

Figures 1 and 2 use a conventional three panel diagram to represent supply and demand curves in the US (left panel), the Rest of the World (right panel) and the World Market (center panel) in which ES
is the US excess supply and ED is the Rest of the World excess demand. World prices and trade quantities are determined in the center panel. Under the absence of domestic support policies, if all farmers in the U.S adopt precision farming techniques and being the U.S a large trading country, an increase in productivity and/or reduction in per unit costs brings about a shift of the U.S. aggregate supply curve to the right as shown in figure 1 (S1 to S2 in left panel). A subsequent increase in the U.S. excess supply, derived from an increase in the domestic supply (ES1 to ES2 in the center panel), results in a decrease in the world price ($P_{w1}$ to $P_{w2}$) and increase in the total quantity traded ($Q_1$ to $Q_2$). Figure 2 relaxes the “no domestic subsidies” assumption. With $P_{us}$ as the support price in the U.S., an increase in the domestic supply ($S_{11}$ to $S_{22}$) due to technological advances, shifts the excess supply from ES11 to ES22 and quantity traded from $Q_1$ to $Q_2$ quite similarly then in the earlier scenario. The kinked excess supply curves are due to the domestic support price such as loan rate. The main difference between the two scenarios would be the difference in the reduction of world price and quantity traded as a function of the supply shift. With price support in the U.S., the reduction in world price is more pronounced than in the free trade scenario. This sets stage for a sensitivity analysis involving the above two scenarios. The linkage between cotton production and trade flows relies on the assumption that precision agriculture would allow farmers to produce more by increasing yield productivity and/or reduced per unit costs. The high yields achieved in crop production in the United States require that large amounts of nutrients be applied to the soil replacing those withdrawn in the production cycle. There has been a long-standing interest in developing technology to more accurately apply fertilizers and other inputs to increase cotton production efficiency. While animal manure and other organic materials contribute to nutrient replacement, commercial fertilizers are the major source of applied plant nutrients. Precision agriculture focuses on optimizing the input usage (of commercial fertilizers) using advanced technology and increase net productivity. The study attempted to analyze the relationship between the technological advances and U.S cotton trade flows by focusing on precision agriculture as a source of a supply shock and simulating the indirect effects using the world cotton model described above. Theoretically as depicted in the figures 1 and 2, there is a decrease in the world prices as a result of rightward shift of U.S excess supply and an increase in the net quantity traded due to technological advances. In the “support price” scenario, reduced world price and expanded production would imply increased subsidies to maintain domestic target prices.

3. Methods and procedures

This section details the tools used to quantify the directional changes in U.S cotton trade flow due to the use of precision agriculture which were discussed in section 1. A “World Cotton Model” (Pan et al., 2004), was used to simulate the two scenarios. The model includes 24 major cotton importers and exporters, such as China, Pakistan, India, Australia, the EU, Turkey, Mexico, the United States and Africa.

3.1. Data

The historic and predicted macro variables (real GDP, exchange rate, population, and GDP deflator) are from the Food and Agricultural Policy Research Institute (FAPRI). Cotton production, consumption, ending stocks, import, and export data are from USDA’s Production, Supply & Demand (PSD) database. The fiber mill consumption and manmade fiber data are from FAO World Fiber Consumption Survey (before 1994), Fiber Organon (after 1994), and from personal contacts in different countries.
3.2. Representative country model

As shown in figure 3, representative country models include supply, demand and market equilibrium for cotton and man-made fibers. In the model, representative country’s cotton is modeled as a sector in a global comprehensive supply and demand framework. Major components of the model include cotton supply and demand sectors, price linkage equations, manmade fiber production, and a textile output equation.

Area sown to cotton is modeled in a two-stage framework. The first stage determines gross cropping area. The second stage uses economic variables (expected net returns) to determine cropping patterns (area allocation) for cotton and major substitute crops. The partial equilibrium model allows each of these countries to be simulated simultaneously, with separate cropping pattern and yield equations. To include the effects of precision agriculture on the world cotton model, we remove US yield and cost equations in Pan et al’s model and let yield and cost exogenously changes based on the assumption we have earlier. Cotton consumption is also modeled in two stages: total domestic fiber consumption and cotton’s share of the fiber consumption. After two decades of rapid development, China has emerged as the world’s largest producer of chemical fiber. Since 1997, consumption of chemical fiber has grown rapidly and has overtaken that of cotton. The share of cotton in total yarn production has declined from 86 percent in 1982 to about 60 percent in recent years. In this model, the weighted fiber price (cotton, wool and polyester) and GDP per capita determine the total fiber consumption, and the price ratio of cotton and other fibers is used to determine the shares of cotton and manmade fiber. Prices for both polyester (as a representative for manmade fibers) and the world cotton price (A-index) are endogenous and determined by world net trade. China’s domestic cotton price is also determined by the domestic production, consumption, net trade, and ending stocks.

3.3. Behavioral equations and elasticities

Table 1 presents a set of stylized model specification for a representative country. The model specifies per capita fiber consumption as a function of the fiber price and per capita income (equation 1). In the second stage, total fiber production was allocated among various fibers based on relative prices (equations 2 and 3). In the supply side, cotton acreage generally was specified as a function of own and competing crop expected net returns or prices and cotton yield is dependent on cotton price and time trend to capture technological change (equation 4). Cotton subsidies are included in the acreage equation. Following Meyer (2002), man-made fibers production was modeled separately as capacity and utilization (equation 5). Capacity equation was specified as function of past five years’ man-made fibers and crude oil prices and utilization rate as a function of recent man-made fiber and crude oil prices.

Cotton exports and imports equations were specified as a function of domestic and international prices (equations 6 and 7). For import equations, international prices were calculated by converting world price into domestic currency equivalent after adding appropriate tariffs. Similarly, for export equations, international prices were calculated by converting world representative price into domestic currency equivalent. Finally, ending stock equation (equation 8) was specified as domestic cotton price, cotton production and beginning stock. Domestic and world prices were solved endogenously based on marketing clearing condition (equations 11 and 12).

Table 2 contains income elasticities for the per capita textile consumption equations as well as own and cross price elasticities for cotton mill demand equations. Income elasticities range from 0.11 to 0.69, the lowest corresponding to South Korea and highest to China. Most of the emerging markets such as China, India, Brazil, and Mexico have income elasticities - above 0.5. At the mill level,
cotton is very responsive to its own price in most of the Asian and African countries/regions. Table 3 reports cotton acreage response elasticities for major producing countries. The short run elasticities of cotton acreage response range from 0.10 to 0.54, with Mexico having the highest value. The long-run acreage response elasticities range from 0.21 to 1.15, with highest in Australia. The relatively large elasticities for Mexico, Australia and Brazil reflect greater flexibility and choice in alternative crops production. Price transmission elasticities from the world to domestic prices are also reported in Table 4. Price transmission elasticities ranged between 0.14 to 0.97 with higher values for countries like Argentina, Brazil and Australia and lower values for China and Africa. The lowest elasticities of price transmission represents that the procurement prices are set by policy and can be treated as being predetermined in these regions at the history.

4. Simulation Results

The summary of the simulation results is presented in Tables 4 to 6. The baseline projection assumes all countries impose same policies as those in 2006. The model is driven by a set of macroeconomic variables such as real GDP, the consumer price index (CPI), exchange rates, and population. Projections for these variables were obtained from the 2006 World and U.S. Agricultural Outlook published by the FAPRI. Projections of other variables such as acreage, yield, and prices for competing crops (e.g. wheat, rice, and corn), and crude oil prices were collected from different sources as mentioned earlier. Under current support programs, simulation results (Table 4) indicate that generalized adoption of precision agriculture in cotton may induce an average reduction of 2.39% in the world cotton price (A-Index) and 5.51% decrease in the U.S cotton price relative to their respective baseline with the highest effects in the first year. From 2007/08 onwards, the price and quantity changes follow a relatively slow decay. Under a relative trade liberalization policy (removal of all subsidies such as the cotton loan program, step 2 payments, counter cycle payments and other subsidies), though the effects of precision agriculture on cotton price (A-index) have the same pattern with the former case, the quantities is relative smaller, by an average of 1.91% and 4.61% respectively. Thus, a more free trade environment for the cotton market results in lower price effects.

Under current policy, production and exports increase on average 2.45% and 3.08% (Table 5). While producer revenues decline (Table 6), export revenues increase, and government subsidy expenditures rise by more than 9%. Under no subsidy scenario, the effects are relatively less pronounced. From a policy standpoint, U.S. cotton producers who choose to participate in government programs receive benefits that assure a target price for cotton of 72 cents per pound. In a free trade environment (no subsidy), U.S. cotton producers will face prices below those possible with present program benefits. This decrease in cotton price received by U.S. farmers is expected to affect U.S. cotton production resulting in reduced export levels. Additionally, the step 2 program benefits provide a price subsidy for the users and exporters of U.S. cotton making U.S. cotton more competitive in world markets. The elimination of the step 2 program is expected to induce a drop in exports as well. These anticipated effects are evidenced in the model results (see Table 5). The effects on U.S. cotton exports are predicted to increase 0.36% less in the no subsidy scenario than the scenario under current policy. The simulation results concur with the directional changes derived in the conceptual framework. Even though the direction of the trade flows including the cotton price decline and the increase in traded quantity were known, the magnitude of the potential impacts was unknown. Our study shows that those effects on prices and revenues might not be negligible. During the 2005 Hong Kong WTO negotiation, US provide a new proposal (USDA-FAS 2005), which significant reduces domestic support, increases market access, and eliminates export subsidies. Given the U.S. position and the strong pressure to reduce agricultural subsidies, the future trends on cotton prices and revenues may not be promising for U.S. producers. More than ever, it would take strong
coordination and consistency in the design of U.S cotton policies, concerning production technologies, domestic subsidies, and trade promotion, to generate the conditions required to foster a competitive and efficient cotton farming sector.

5. Conclusions

This study shows that investments in precision agriculture, although improving cotton yields and reducing producing cost, may have non negligible indirect effects on world trade markets. Under existing farm programs, these improvements may increase government expenditures. At the same time, US cotton farmers may suffer important losses in absence of such programs. These results imply that technology improvements like Precision Agriculture may have two side effects: on one side, they may increase total social welfare if farmers adopt the new technologies; on the another side, farmers could be reluctant to adopt the technology if the net impact would imply losses due to lower prices and revenues (the effects of income loss due to supply increases, government payments loss due to farm program changes, etc.). Although yield increase as long as production increase would decrease the world cotton price (A-index) given the world demand constant, under current policies, because the loan rate, target price could guarantee farmers’ minimum net income, farmers’ net income actually would increase. However, farmers would suffer some losses if the current farm programs such as target price, loan rate, step-2 programs, and counter cycle payments disappear. Whether farmers will adopt new technologies would depend on whether their net income increase due to the higher yields and/or cost reduction can compensate the losses due to lower market prices.

The results of this study also suggest that any changes in policy and new technology improvements in the agriculture sector should consider farmers’ net welfare changes. Any changes which only consider one side (yield improvements and cost reductions) and ignore the potential indirect impacts of the other side (lower prices and revenues) may not provide the desired long term benefits to the cotton sector.
References


Link:http://agron.scijournals.org/cgi/content/full/95/4/949.


Figure 1. Cotton and Global Cotton Market- No Subsidies Scenario
Figure 2. Cotton and Global Cotton Market- With Subsidies Scenario
Figure 3. Representative Country
<table>
<thead>
<tr>
<th>Equation</th>
<th>Variable</th>
<th>Behavior Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Per capita fiber consumption</td>
<td>$PC_f = \alpha_0 + \alpha_1P_f + \alpha_2l$</td>
</tr>
<tr>
<td>2</td>
<td>Share of cotton mill use</td>
<td>$DS_c = \beta_0 + \beta_1(P_e / P_s)$</td>
</tr>
<tr>
<td>3</td>
<td>Share of man-made fiber mill use</td>
<td>$DS_m = \beta_0^m + \beta_1^m(P_e / P_s)$</td>
</tr>
<tr>
<td>4</td>
<td>Cotton supply</td>
<td>$S_{c,t} = \kappa_0 + \kappa_1(P_{c,t-1} / P_{o,t-1})$</td>
</tr>
<tr>
<td>5</td>
<td>Man-made fiber supply</td>
<td>$S_{m,t} = \kappa_0^m + \sum_{k=1}^5 \kappa_1^m(P_{m,t-k}) + \sum_{k=1}^5 \kappa_2^m(P_{g,t-k})$</td>
</tr>
<tr>
<td>6</td>
<td>Cotton imports</td>
<td>$I_c = \phi_0 + \phi_1(P_e / WP_e (1 + T))$</td>
</tr>
<tr>
<td>7</td>
<td>Cotton exports</td>
<td>$E_c = \phi_0 + \phi_1(P_e / WP_e (1 - \tau))$</td>
</tr>
<tr>
<td>8</td>
<td>Cotton ending stock</td>
<td>$K_{c,t} = \rho_0 + \rho_1(S_{c,t}) + \rho_2(P_c) + \rho_3K_{c,t-1}$</td>
</tr>
<tr>
<td>9</td>
<td>Cotton price linkage</td>
<td>$P_c = \gamma_0 + \gamma_1WP_c$</td>
</tr>
<tr>
<td>10</td>
<td>Polyester price linkage</td>
<td>$P_m = \gamma_0 + \gamma_1WP_m$</td>
</tr>
<tr>
<td>11</td>
<td>Marketing clearing cotton</td>
<td>$\sum I_c = \sum E_c$</td>
</tr>
<tr>
<td>12</td>
<td>Marketing clearing man-made fiber</td>
<td>$\sum (S_{m,t}^c + S_{m,t}^i) = \sum (DS_m * PC_f * PO)$</td>
</tr>
</tbody>
</table>

Note: The superscript e and i refers to a country which is assumed to export and import cotton and man-made fiber, respectively. The capital letter PC, S, D, DS, P, WP, I ,E, K, and PO represents per capita consumption, supply, share of mill use, domestic price, world price, imports, exports, ending stock, and population respectively. The subscripts f, c, m, w, and o represent fiber, cotton, man-made fiber, world, competing crops respectively and t, t-1, t-k represent current time period, one lag, and k lags. T and τ represent tariffs rate and export subsidy rate; n represents number of countries included in the model; and $\alpha, \beta, \kappa, \phi, \rho$, and $\gamma$’s are estimated coefficients.
### Table 2. Income elasticities of textile consumption and price elasticities of cotton mill use for major countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Income Elasticities</th>
<th>Price Elasticities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For Textile</td>
<td>Cotton</td>
</tr>
<tr>
<td>US</td>
<td>0.15</td>
<td>-0.24</td>
</tr>
<tr>
<td>Australia</td>
<td>0.13</td>
<td>-0.05</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.11</td>
<td>-0.57</td>
</tr>
<tr>
<td>Taiwan</td>
<td>0.11</td>
<td>-0.50</td>
</tr>
<tr>
<td>Japan</td>
<td>0.14</td>
<td>-0.57</td>
</tr>
<tr>
<td>EU-15</td>
<td>0.12</td>
<td>-0.39</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.58</td>
<td>-0.27</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.53</td>
<td>-0.15</td>
</tr>
<tr>
<td>China</td>
<td>0.69</td>
<td>-0.57</td>
</tr>
<tr>
<td>India</td>
<td>0.56</td>
<td>-0.44</td>
</tr>
<tr>
<td>Pakistan</td>
<td>0.52</td>
<td>-0.28</td>
</tr>
<tr>
<td>Africa</td>
<td>0.55</td>
<td>-0.74</td>
</tr>
<tr>
<td>World</td>
<td>0.30</td>
<td>-0.28</td>
</tr>
</tbody>
</table>

Source: Pan et al. (2007).
Table 3. Cotton price transmission and supply elasticities

<table>
<thead>
<tr>
<th>Countries</th>
<th>Regions</th>
<th>Price Transmission Elasticities</th>
<th>Acreage response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Short-Run</td>
<td>Long-run</td>
</tr>
<tr>
<td>US</td>
<td>Delta</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Southeast</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Southwest Irrigated</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Southwest Dryland</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>West</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>0.93</td>
<td>0.52</td>
<td>1.15</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.97</td>
<td>0.50</td>
<td>0.74</td>
</tr>
<tr>
<td>China</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yellow River</td>
<td>0.11</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>Yantze River</td>
<td>0.10</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Southwest</td>
<td>0.11</td>
<td>0.30</td>
</tr>
<tr>
<td>Africa</td>
<td>0.41</td>
<td>0.11</td>
<td>0.58</td>
</tr>
<tr>
<td>India</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>North</td>
<td>0.12</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>West</td>
<td>0.12</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>EU-15</td>
<td>0.96</td>
<td>0.44</td>
<td>1.05</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.87</td>
<td>0.54</td>
<td>0.91</td>
</tr>
<tr>
<td>Pakistan</td>
<td>0.83</td>
<td>0.13</td>
<td>0.26</td>
</tr>
<tr>
<td>Argentina</td>
<td>0.76</td>
<td>0.24</td>
<td>0.48</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>0.79</td>
<td>0.25</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Source: Pan et al. (2007).
Table 4. Potential effects of precision agriculture on world and U.S. farm price.

<table>
<thead>
<tr>
<th></th>
<th>2006/07</th>
<th>2007/08</th>
<th>2008/09</th>
<th>2009/10</th>
<th>2010/11</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A-Index</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Current Policies</td>
<td>-4.50%</td>
<td>-3.54%</td>
<td>-1.90%</td>
<td>-1.32%</td>
<td>-0.68%</td>
<td>-2.39%</td>
</tr>
<tr>
<td>No Subsidies</td>
<td>-4.01%</td>
<td>-1.65%</td>
<td>-1.64%</td>
<td>-1.22%</td>
<td>-1.05%</td>
<td>-1.91%</td>
</tr>
<tr>
<td><strong>U.S. Farm price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Current Policies</td>
<td>-7.16%</td>
<td>-6.95%</td>
<td>-5.01%</td>
<td>-4.77%</td>
<td>-3.64%</td>
<td>-5.51%</td>
</tr>
<tr>
<td>No Subsidies</td>
<td>-6.63%</td>
<td>-4.59%</td>
<td>-4.29%</td>
<td>-4.19%</td>
<td>-3.37%</td>
<td>-4.61%</td>
</tr>
</tbody>
</table>
Table 5. Potential effects of precision agriculture on US cotton production and exports

<table>
<thead>
<tr>
<th></th>
<th>2006/07</th>
<th>2007/08</th>
<th>2008/09</th>
<th>2009/10</th>
<th>2010/11</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Current Policies</td>
<td>2.90%</td>
<td>2.67%</td>
<td>2.29%</td>
<td>2.38%</td>
<td>2.03%</td>
<td>2.45%</td>
</tr>
<tr>
<td>No Subsidies</td>
<td>2.85%</td>
<td>2.31%</td>
<td>2.04%</td>
<td>2.02%</td>
<td>1.99%</td>
<td>2.24%</td>
</tr>
<tr>
<td><strong>Export</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Current Policies</td>
<td>3.39%</td>
<td>3.46%</td>
<td>3.04%</td>
<td>2.95%</td>
<td>2.56%</td>
<td>3.08%</td>
</tr>
<tr>
<td>No Subsidies</td>
<td>3.31%</td>
<td>2.67%</td>
<td>2.62%</td>
<td>2.50%</td>
<td>2.49%</td>
<td>2.72%</td>
</tr>
</tbody>
</table>
Table 6. Potential effect of precision agriculture on farmers revenues and government support

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Producer Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Current Policies</td>
<td>-4.47%</td>
<td>-4.15%</td>
<td>-2.83%</td>
<td>-2.51%</td>
<td>-1.69%</td>
<td>-3.13%</td>
</tr>
<tr>
<td>No Subsidies</td>
<td>-3.92%</td>
<td>-2.65%</td>
<td>-2.34%</td>
<td>-2.26%</td>
<td>-1.96%</td>
<td>-2.62%</td>
</tr>
<tr>
<td><strong>Export Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Current Policies</td>
<td>-1.26%</td>
<td>-0.21%</td>
<td>1.09%</td>
<td>1.59%</td>
<td>1.86%</td>
<td>0.61%</td>
</tr>
<tr>
<td>No Subsidies</td>
<td>-0.83%</td>
<td>0.48%</td>
<td>0.94%</td>
<td>1.26%</td>
<td>1.41%</td>
<td>0.65%</td>
</tr>
<tr>
<td><strong>Government Support</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Current Policies</td>
<td>13.82%</td>
<td>11.67%</td>
<td>8.36%</td>
<td>6.68%</td>
<td>6.10%</td>
<td>9.33%</td>
</tr>
<tr>
<td>No Subsidies</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>