Estimating Vulnerability of U.S. Peanut Producers to Changes in Farm Support and Trade Liberalization

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ABSTRACT
In the paper, we make an attempt to estimate the supply of farmer stock peanuts in the Southeastern Region of the U.S. and evaluate production effects of the recent changes in farm support policies and of trade liberalization that have affected prices. The choice of estimation methodology is dictated by the unavailability of suitable time-series data due to heavily regulated nature of the U.S. peanut markets before 2002. Supply estimation is performed by estimating farm-level supply using cross-sectional survey data on farm-level costs and returns. Results show that producers not able to expand peanut acreage are likely to be vulnerable to price reductions, as there might exist economies of scale. Production on dry land is likely to remain unprofitable at the current price levels. The analysis is complicated by severe multicollinearity problems and noisiness of the input data explained by the fact that many input variables may be inverse proxies for land productivity, which varied because of the constraints imposed by the supply management policies.

Keywords: ag. production, supply adjustment, peanuts, Farm Bill.
JEL Classifications: Q120, Q180, Q150, D610.
**Introduction**

In the current version of the paper, we make an attempt to estimate the supply of farmer stock peanuts in the Southeastern Region of the U.S. and evaluate short and long-run production and welfare effects of the recent changes in farm support policies and of trade liberalization. The choice of estimation methodology is dictated by the unavailability of suitable time-series data due to heavily regulated nature of the U.S. peanut markets before 2002. Supply estimation is performed by first estimating farm-level supply using cross-sectional survey data on farm-level costs and returns and then aggregating the results into a regional supply function using aggregate data and industry facts.

The objective is to find how vulnerable the U.S. peanut production has become after the 2002 Farm Act to trade liberalization and the increase of production by major peanut producing countries. Knowing this is important because gradual agricultural trade liberalization under the WTO and regional agreements increases competitive pressure on domestic producers, and peanut production is of vital importance to the rural communities, particularly the Southeast. Based on USDA Census of Agriculture, many counties in the Southeastern region of the U.S. derive 50-70% of their income from peanut farming. Consequently, peanut policies have played a major role in maintaining rural income in these regions of the U.S. (Revoredo and Fletcher, 2002).

Straightforward estimation of the U.S. peanut supply was virtually impossible before 2002, when peanut production was regulated by the supply management policies (the quota system) under which production of edible peanuts (the bulk of the crop) was fixed by the peanut quota, and the price of in-quota peanuts was also fixed at an artificially high level (~$610/ton). Besides, there was little practical sense in such estimations, as the quota was always filled and the purchasing price maintained. The 2002 Farm Act replaced the quota with the Marketing Loan Program that lifted the quantity restrictions and drastically reduced the producer price floor defined by the Marketing Loan Rate. This change in the support regime caused somewhat dramatic shifts in the peanut production, both inter- and intra-regional, as more efficient producers increased their acreage and less efficient shrank/quit production (Dohlman, et al., 2004).

This domestic policy change is being accompanied by gradual trade liberalization, particularly by reductions of agricultural TRQs under the obligations of the WTO, NAFTA, and other regional agreements which, together with increasing production by Argentina, Brazil, China, and India, reduces peanut prices and puts serious competitive pressure on the domestic peanut producers (de Gorter et al., 2001). We believe that this situation calls for a realistic evaluation of the U.S. peanut production and for an analysis of its competitive position in the fast changing world peanut markets.

Since too little time has passed since 2002 to make time-series data estimation possible, we propose estimation of peanut supply using farm-level data. Standard models of individual farm supply accommodate the farm-level nature of the data, such as planting decisions, farm-level yields, individual farm characteristics, crop rotation history, and (subjective) yield risk estimates (Houck and Ryan, 1972). However, acreage response studies typically require panel data spanning at least 20 years of observations. Even if these data were available for peanuts, it would be mostly from the times when the quota system was in force, so that output and price variations would hardly be sufficient.

As a viable alternative, we propose estimating aggregate supply by using cross-sectional farm-level data for production or cost function estimation followed by modeling on-
farm profit maximization decisions and aggregation of the resulting farm-level supplies. Production or cost function estimation of cross-sectional data is appropriate in an economic environment distorted by price/quantity controls that distort producer profit maximizing behavior. Besides, it permits inclusion of individual farm variables that can not be measured accurately with aggregated data and eliminates distortions caused by annual yield variations and technological and policy changes. Finally, farm-level data has a clear advantage over aggregate data as the latter introduces a bias that stems from “averaging out” much of variation in individual acreage responses, leading to underestimation of supply elasticities (Ferris, 1998).

The proposed estimation methodologies are either direct production or cost function estimation (Pope and Chavas, 1994) or, preferably, estimation of production or cost efficiency using stochastic frontier analysis (Coelli), which is an econometric technique based on assuming a specific functional form for the cost/production frontier (Fare, Grosskopf, and Lovell, 1994). Apart from estimates of the “efficient” cost function/frontier, the stochastic frontier approach produces individual inefficiency estimates, as well as estimates of economies of scale. This makes it possible to correct the estimated cost function for the changes in relative producer efficiency, such as the recently observed shifting of peanut production to efficient producers or areas with better climate and soil conditions. We expect to be able to evaluate the changes in production volume by utilizing regional data on the shifts in peanut production that have occurred in the last two years, which is becoming increasingly available from various USDA and local sources.

The cross-sectional data used in the cost function analysis come from a comprehensive peanut farm costs and returns survey conducted by the NASS between March and April of 2002. No survey of similar magnitude has been conducted after 2002, which makes this survey the best data source for the proposed research. While most of the respondents to the 740 survey questionnaires were from Georgia (the largest peanut producing state), the data can be complemented by similar surveys conducted in other states. The survey furnishes data on a wide range of producer characteristics, such as farm production costs/returns, acreage seeding, land operated and commodities produced, farm assets and debts, and demographic characteristics.

The estimates of the peanut production (or cost) function are used in constructing an aggregate supply function by solving a representative producer’s profit maximization problem, in which the farm profit function is maximized with respect to acreage and other input decisions. In modeling producer decisions on a micro-level, it is possible to include short-run adjustments to price shocks, expectations, and risk aversion, which would provide a more accurate basis for aggregation.

Changes in Peanut Production Support Policies and Industry adjustment
The 2002 Farm Act dealt away with the supply management system that, being preceded by a similar system of acreage allotments, existed since 1981. Under the supply management system, both price and quantity controls were imposed on peanut production. The quantity/volume of peanuts grown for domestic consumption for “edible purposes” was limited by an annual quota limit, which was fixed and belonged to some peanut farmers and not to others.
The advantage of growing quota peanuts was in the fact that they could be sold at a price not less than the mandated support price that ranged from $600 to $680 per ton during the 1990s and early 2000s. Any additional quantities produced but not covered by the quota (the so-called “additionals”) had to be exported at world prices that typically ranged between $300 and $375 per ton). If these “additionals” were not exported, they had to be crushed at a value of approximately $200-$250 per ton. As a result, some producers rented quota quantities (in lbs) from quota owners, which was equivalent to buying the right to grow domestic “edible” peanuts. This support regime created distortions in peanut markets, affecting not only production patterns and efficiency, but also the land prices that were often inflated due to the quota allocated to the land.

The 2002 Farm Act replaced the quota system with a Marketing Assistance Loan Program (MLP) that lifted the quantity restrictions on peanut production and introduced a per-unit revenue floor in the form of marketing loan rate. Under the MLP, producers can move the crop into the marketing loan (government storage) as a pledge for a (current) loan rate of $355 per ton (the producer per-unit revenue floor). At the end of the post-harvest period of nine months, farmers can either forfeit the loan (give up the “collaterized” peanuts and keep the loan rate) or repay it at the lower of the loan rate or the loan repayment rate that is set equal to the “weekly posted prices” and is announced by the USDA (Westcott, Young, and Price).

During the last three years, the most important feature of peanut supply has been dramatic shifts in the patterns of peanut acreage not any longer restricted by the quotas. While acreage dropped in the unirrigated areas of the Southwest, it expanded in the Southeast due to more favorable growing conditions. The issue at present is that domestic production (2,100,000 tons) so far exceeds the sum of domestic consumption (about 1,500,000 tons) and exports (400,000 tons). As a result, the left over stocks reached nearly 600,000 tons in 2005. Another figure is 905,000 tons remaining in the loan as of March 1, 2005, the original loan volume being 1,950,000.

While the acreage increased by 6 percent last year nationwide (after being down 2 percent the previous year), the Southeast has increased acreage by 13 percent. The Virginia-Carolina region increased acreage by 11 percent after a previous year 15 percent decrease. The Southwest plantings dropped 12 and 4 percent in the last and the previous years respectively, due to the limited water supply.

The expansion is not demand driven, however, as the prices have been steady and the stocks of in-shell and shelled peanuts have increased by 5 and 25 percent respectively. In spite of the stock accumulation, domestic consumption has increased by about 14 percent (the U.S. demand projected to be 1,625,000 farmer stock tons), but the exports grew by only 10 percent, due to the competition from the Chinese producers. At the same time, the U.S. domestic prices remain higher than the world prices.

\footnote{To the best of our knowledge, there has been no recent research on the impact of peanut quota on land prices, mainly due to the complexity of both the old and the new support regimes. However, under a poundage quota regime, peanut quota was a farm asset, which had a significant impact on land’s sale and rental values. At the same time, the quota poundage could be separated (sold) from the farm (Fletcher \textit{et al.}), and its value was approximated by the quota rental rate, which suggests that the land could also be sold with or without the quota.}
However, there are reasons to believe that the acreage expansion, particularly in the Southeast, is supply driven for the following reasons:

- Availability of new planting areas are available (beyond the former quota tracts) not acreage allotments), which might also be less subject to disease.
- Lack of profitable alternative crops. Cotton and corn, the main alternative crops, are allegedly not as profitable as peanuts.
- High costs of fertilizer and nitrogen – an additional explanation of low cotton and corn profitability, as peanuts require smaller inputs of both.
- With the cotton prices continuing to drop, the same equipment (except for harvesting) can be used for growing peanuts.

In a situation that is getting close to oversupply, it is reasonable to expect the “option-to-purchase” contracts to remain dominant in the in-shell peanut markets, as it has been suggested that the primary purpose of the option clause is to prevent shellers’ overstocking.

Last year, with the future crop prices unknown because of the increase in peanut acreage, peanut processors (the shellers) wanted to “option” to buy later when acreage is known. As a result, the option premiums have soared to $120 per ton in the Virginia-Carolina region, making the net farmer price of $475-498/ton, and $70/ton in the Southwest (for Spanish peanuts). In the Southeast, the option in 2004 was $45/ton (plus a grade premium). This might be indicative of the lower production costs in the region, as well as of the fact that producers do not have many suitable alternatives to planting peanuts.

However, anticipated acreage expansion and inventory buildup in 2005 has caused a drop in the option contract price: the shellers offered a $20/ton option premium on only 1,500lbs/acre. While the grower acceptance of the offered contracts is good in the new areas, even with the meager $20 premium, the response has been slower in the traditional growing areas.

Overall, the MLP has been successful, and so far the loans have been repaid and all peanuts were eventually sold. However, the danger of massive forfeiting in case of a surplus crop remains. This has caused some concerns about restricting planting acreage sometime in the future. The only issue related to the program operation is the anticipated 2007 budget reductions by approximately $60-70$ million used for paying farmer’s handling fees and storage. As a result, the current $355 loan rate can drop to $300, while currently a farmer is believed to break even at the $355 loan rate and a yield of about 3,600 lbs per acre. The 2002 survey data analyzed in this paper confirm these figures more or less and show that farmers can not afford planting on non-irrigated land anymore.

Methodology
The choice of estimation methodology is dictated almost entirely by data availability. As was mentioned in the previous section, time series data from the period when peanut production was subject to the supply management policies can hardly be used for supply estimation because the level of regulation was too heavy to allow sufficient price and quantity variation: with both price and quantity of peanuts grown for edible purposes fixed, production was quite stable and insensitive to market signals, as the prices rarely exceeded their quota values. Besides, peanut production was tied to specific land tracts that were not necessarily the land that would be used in the absence of the quota system. The reason for this is that the original quota “acreage allotments” were allocated more than half a century ago and, since
then, the pattern of agricultural land in the region changed so that, even assuming the original allocation was “efficient” in one way or another, there is no reason to believe that it remained the same over time. However, while the rigid quota land allocation might have been distortionary for peanut production patterns, the possible additional distortionary effects of quota ownership might have been mitigated by the possibility to rent quota: an inefficient (or less productive) quota owner could always rent the quota out to another grower willing to pay the quota rent equal to the owner’s opportunity cost but able to more than compensate for it due to his “comparative advantage” (by using better abilities or more efficient production practices). The practice of quota renting was quite common, as our survey data indicates that, in 2001, only 43 percent of quota peanuts were produced under “own quota” (57 percent was produced under the quota rented from the owners).

The only peanut production that was unregulated by the quota was that of peanuts grown for crush or other “non-edible” purposes. However, its volume was insufficient to be indicative of the total supply (about 19% of total production in the region in 2001).

As the supply management policies in peanut production were abandoned only three years ago, there is not enough time over which one could observe sufficient price and quantity variability to estimate peanut supply elasticity. At the same time, the abandonment of quota system and gradual reduction of the peanut tariff rate quotas makes it important to know how domestic production would respond to price signals, as well as how vulnerable the Southeast peanut producers are to increasing competition from the world peanut producers.

One of the ways to deal with the issue of estimating farm-level supply is to utilize the farm-level production data for estimating individual (representative) farm supply responses, which can be aggregated into a regional supply function. To do this, one has to start with estimating either an individual farm supply or cost function. As no price or quota ownership information is used in this estimation, the estimates are free of the market distortions imposed by the supply management policies. The estimated production function can then be used to derive a cost function by minimizing it with respect to the inputs for a given level of output. Using either current or former input prices in this exercise would generate a current or a “former” cost function, the usefulness of the latter being in the fact that it can be compared to the actual cost data from the former period. In case of estimating a farm production cost function, such comparison would not be possible.

The resulting cost function can then be used in constructing an individual farmer’s profit function, which is maximized with respect to the farm output in question. The optimal production volume, being a function of input and output prices, represents a farm-level supply response.

The farm-level supplies can then be aggregated into a regional supply function that can be used in evaluating supply responses to price changes, as well as to other changes in farm support policies.

It is important to note that, during the three years after the new Farm Bill, the actual farmgate prices were determined primarily by the marketing loan repayment rate and the “option” premiums paid by the crop processors. While the option premium component is volatile and depends on the domestic demand and world prices (one might also suggest the actual producer costs if the processors are oligopsonistic), the loan rate has been stable at $355 per ton. However, it is anticipated that the loan rate itself will be lowered by the next farm bill by excluding the storage and handling expenses so far born by the government, as the government is trying to manage the growing deficit.
However, this approach requires imposition of certain restrictions and assumptions. Using the farm-level production function requires an assumption of identical farmers or at least several groups of identical producers that differ by some characteristics essential for productivity, like soil type, farm size, or demographic factors.

Technically, we use a general model of input and output pricing adjusted for the peculiarities of peanut production in the southeastern region of the U.S. and to accommodate the nature of the farm level data used in the analysis. The model can calibrated with the data estimation results, which permits evaluation of the impacts of exogenous shocks on the peanut farm sector. The advantage of this approach is that it is well grounded in economic theory and allows accommodation of various farm-level data. This allows evaluation of the impacts of input prices, legislatively changes, and demographic characteristics, as opposed to aggregate supply estimation models that only accommodate the impact of the changes in output price.

Defining an individual producer production function as

\[ Y_i = f(X_i), \]

where \( X_i \) is a vector of inputs, such as acreage, labor, seeds, chemicals, materials, etc.), we can safely assume that, regardless of the peculiarities of the output market (i.e., price supports or production limits), the producer minimizes (variable) costs for every given level of output:

\[
\min_{X_i} C_i = \sum_k w_k x_{ki} \quad \text{s.t.} \quad Y_i = f(X_i).
\]

(note: \( Y \) also depends on the crop rotation practices and what it is rotated with, but we don’t have the information about it)

Minimization produces individual input demand functions of the output level and input prices:

\[ x_k = x_k(Y, W), \quad \forall k \]

and thus the cost function \( C_i = \sum_k w_k x_{ki}(Y, W) = C_i(Y, W), \) where \( W \) is a vector of input prices.

Having thus calibrated a cost function, a producer’s profit maximization problem can be solved yielding individual (farm-level) output supplies and input demands (via the Hotelling’s lemma):

\[
\max_y \pi_i = PY_i - C_i(Y, W).
\]

The supply is implicitly determined by \( P_i = \frac{\partial C_i}{\partial Y_i}, \) and input demands are obtained by differentiating the resulting profit function, \( \pi_i(P, W), \) with respect to the input prices. The complexity of this modeling is constrained only by the lack of data and the risk of introducing too many measurement errors (?). The parameters of the production function can be estimated separately for sub-samples of producers or different size, using irrigated or dry land, or quota owners and renters.

The resulting input supplies \( Y_i(P, W) \) can be aggregated into the regional supply function by assuming identical producers in a certain size or land type category. Not including the alternative crops (ignoring possibilities of substitution) is less harmful in this particular case because, currently, the main alternatives to peanuts in the Southeast – cotton
and corn, are not profitable enough to warrant substitution. On the other hand, the previously limited land allocated to quota peanuts is now in ample supply, which has translated in significant increases in the peanut acreage during the last three years.

Potential problems with this kind of modeling include lack of actual input prices and the impossibility to include all disaggregate inputs. The price of certain inputs that are heterogeneous in quality (like chemicals for example) can be approximated by a price index as a weighted average of individual product prices. However, the most important issue is that even a small imprecision in estimating the production function coefficients can translate into big mistakes in the cost function because of the complex expressions for the cost function estimation parameters. For a Cobb-Douglas production function of only two inputs, land and labor:

\[ Y_i = aA_i^\alpha L_i^\beta, \]

cost minimization produces the following cost function:

\[ C_i = a \left[ \frac{1}{\alpha+\beta} \left( \frac{\beta}{\alpha} \right)^{\alpha+\beta} + \left( \frac{\alpha}{\beta} \right)^{\alpha+\beta} \right]^{\alpha+\beta} Y_i = \frac{1}{\alpha+\beta} \left( \frac{\alpha}{\beta} \right)^{\alpha+\beta} W_A^\alpha W_L^\beta \]

While the powers of \( Y, W_A, \) and \( W_L \) are not complicated, the constant term can be very distorted in case of measurement errors in \( \alpha \) and \( \beta \).

Defining the constant term as \( R \), the resulting output supply is derived as

\[ P = R \left( \frac{1}{\alpha + \beta} \right) Y_i \left( \frac{1}{\alpha + \beta - 1} \right) W_A^\alpha W_L^\beta \]

\[ Y = \left( \frac{R}{\alpha + \beta} \right) P^{1-(\alpha+\beta)} W_A^{\alpha+\beta-1} W_L^{\alpha+\beta-1} = R'P^\alpha W_A^\alpha W_L^\alpha \]

Note: these derivations only apply to the cases of interior (unconstrained) solution to the profit maximization problem, which rules out the case of increasing returns to scale, whence infinite production is optimal.

More generally, assuming a production function of the form

\[ Y = a \prod_k x_k^{\alpha_k} \]

yields cost function of the form

\[ C = AY^{1/r} \prod_k W_k^{\alpha_k/r}, \]

where \( A \) is a constant (function of \( a \) and \( \alpha \)'s), and \( r = \sum_k \alpha_k \).

Competitive profit maximizing decisions imply

\[ P = \frac{A}{r} Y^{1-r} \prod_k W_k^{\alpha_k/r} \]
and
\[ Y = \left( \frac{A}{r} \right)^{r-1} P^{r-1} \left( \prod_{k} w_k^{a_k/r} \right)^{1-r}. \]

It is clear that the expression \( \left( \frac{A}{r} \right)^{r-1} \) can translate small errors in the estimates of the production function coefficients into significant mistakes. However, the expression for supply elasticity with respect to price is not very complex due to the Cobb-Douglas functional form:
\[ \varepsilon_p = \frac{r}{1-r}. \]

Although this approach is wrought with numerous flaws, particularly with the restrictions imposed by the theory and the need to put up with particular functional forms and only a limited number of inputs, modeling farm-level supply is a convenient way of circumventing the difficulties of estimating aggregate farm-level supply due to the distortions imposed by farm support policies. This model ignores the producer’s utility function and thus risk aversion. It is possible to introduce risk aversion into the model, accounting not only for the expected value but also for variance of the gross return. Defining \( \sigma^2 = E[Y] \sigma^2 \rho \) as the expected variance of the gross returns, and the utility function as \( u = \phi_0 + \phi_1 E[\pi_i] - \phi_2 \sigma^2 \) results in implicit input demand functions containing the risk premium \( X \) (such that \( u(E[\pi_i], \sigma^2) = u(E[\pi_i] - X, 0) \)).

Maximization of the utility function with respect to acreage, for example, shows that, with risk aversion, the expected marginal revenue product of land is no longer equated to rent, but to the sum of land rent and the marginal risk premium of acreage rented:
\[ E[P] \frac{\partial E[Y]}{\partial x_A} = w_A + \frac{\partial X}{\partial x_A} \]

Thus, under risk aversion, input prices equal the inputs’ marginal revenue products corrected for the average risk premium, which results in smaller supply under increasing returns to scale. However, estimating producer risk aversion requires time series data, something that we do not have. On the other hand, it is possible in principle to infer the risk aversion parameters from the estimates of the production function and actual producer production decisions.

**Data description and results**
The data used in the analysis come from the 2002 Southeast peanut farm costs and returns survey. The survey was conducted by the Georgia NASS in cooperation with Alabama and Florida NASS and sponsored by the National Center for Peanut Competitiveness, National Peanut Board, Southern Peanut Farmers Federation, University of Georgia, Auburn University, and the University of Florida. The survey was conducted between March and April of 2002.

The survey questionnaire contains a wide array of questions grouped by several topics.
into the following components: land operated and commodities produced, peanut acreage and seeding, farm production costs and returns (seeds, fertilizer, chemicals and pesticides, labor, vehicles and tractors, irrigation, peanut quota ownership and renting, peanut marketing and miscellaneous expenses and other crop costs), as well as producer demographic characteristics.

Of the 740 questionnaires distributed across the Southeast peanut production area, only 232 growers responded. The returned questionnaires resulted in 189 questionnaires with some input quantity and expense data.\(^2\) The largest part of the respondents (87 percent) are peanut growers from Georgia, which is the largest peanut producing state in the country, while respondents of Alabama and Florida represent much smaller part of the sample (10 and 3 percent respectively).

In the production function analysis, we mostly concern ourselves with variable inputs; the most important being land, labor, fertilizers, and pesticides. The cost of energy (fuel and electricity) is also important, particularly for the irrigated land where production requires higher energy inputs. We prefer to assume a Cobb-Douglas production function for the sake of its theoretical tractability, but also experiment with the translog and linear specifications. The software used in the analysis is STATA (version 8.0).

Preliminary analysis reveals that there is a high degree of correlation between the total output and each of these variable inputs. The most clear dependence is, obviously, between the output and acreage. Graphically, the logarithms of output (in lbs) and acreage are almost perfectly linearly related:

Least squares regression analysis produces the following results:

| InYlbs     | Coef.  | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|------------|--------|-----------|-------|-----|---------------------|
| lnLand     | 1.078796 | 0.0222573 | 48.47 | 0   | 1.034942  1.12265    |
| _cons      | 7.616245 | 0.1025818 | 74.25 | 0   | 7.414125  7.818366   |

Number of obs 232
F(  1,   230) 2349.28
Prob > F 0
R-squared 0.9108

\(^2\) The main reason for the low (or rather incomplete) response rate is perhaps the sheer length of the questionnaire (more than 2000 entries), which was difficult to complete.
After de-logging, this suggests a function of the form \( Y = 2030 \times A^{1.079} \) which, considering that average sample acreage was 84.5 acres, suggests an average yield of 2,882 lbs/acre. This low value is explained by the high proportion (65%) of dry (un-irrigated) land planted with peanuts.

There is also a noticeable correlation between total farm output and labor in hours (both own and hired):

\[
\begin{array}{cccccc}
\text{Ln(Y)} & \text{Coef.} & \text{Std. Err.} & t & P>t & \text{[95% Conf. Interval]} \\
\text{Ln(hrs)} & 0.809825 & .0524046 & 15.45 & 0.000 & .7065093 0.9131397 \\
_\text{cons} & 7.337984 & .3307255 & 22.19 & 0.000 & 6.685962 7.990006 \\
\end{array}
\]

Number of obs = 209
F( 1, 207) = 238.8
Prob > F = 0
R-squared = 0.5357
Adj R-squared = 0.5334
Root MSE = 0.9613

Likewise, there is correspondence between output and the seed input:
Number of obs 171
F( 1, 169) 192.72
Prob > F 0
R-squared 0.5328
Adj R-squared 0.53
Root MSE 1.0196

<table>
<thead>
<tr>
<th>lnYlbs</th>
<th>Coef.</th>
<th>Std. Err.</th>
<th>t</th>
<th>P &gt;</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(seed)</td>
<td>0.787793</td>
<td>0.0567475</td>
<td>13.88</td>
<td>0</td>
<td>0.6757676 0.899818</td>
</tr>
<tr>
<td>_cons</td>
<td>5.536971</td>
<td>0.4934268</td>
<td>11.22</td>
<td>0</td>
<td>4.562897 6.511045</td>
</tr>
</tbody>
</table>

Realistically assuming that the peanut growers in the Southeast faced the same prices of fertilizers, chemicals, and materials during the survey period justifies using the variable cost of these inputs in production function estimation.  

Plotting the output against total variable costs (defined above) also reveals plausible correlation.

However, estimation of the production function in its entirety is wrought with the issues of multicollinearity. Estimation of the function

\[ \ln(Y) = \text{const} + \ln(\text{Acreage}) + \ln(\text{Labor}) + \ln(\text{seeds}) + \ln(\text{other VC}) \]

produces the following results:

<table>
<thead>
<tr>
<th>lnYlbs</th>
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<th>t</th>
<th>P &gt;</th>
<th>[95% Conf. Interval]</th>
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3 It is not uncommon to use input costs when the inputs are unmeasurable in physical quantities and their price variability is negligible (Battese and Coelli, 1995).
The labor and seed input coefficients are hardly significant and have incorrect signs. The results do not change significantly when the total labor input (in hours) is replaced with either operator’s own labor, operator’s household labor, or hired (paid) labor. One of the reasons for the wrong sign of the labor coefficient may be that the estimation is made of the pooled sample and does not account for the different land quality/productivity, which is particularly important because the peanut quota was assigned to specific land tracts more than half a century ago, since when the quality of some tracts had deteriorated. From this point of view, labor and perhaps the seed input can be considered (imperfect) inverse proxies for the land quality. The insignificance of operator’s own labor may also partly be due to the fixed amount of operator’s time.

Another, more obvious reason for these results is multicollinearity, as the acreage (lnLand variable) is highly correlated with the rest of the regressors, which is not unusual in agricultural production analysis. Multicollinearity is a condition of highly correlated regressors that leads to inflated variance of parameter estimates. For example, in a model with two explanatory variables, the variance of a parameter \( k \) is

\[
\text{Var}[b_k] = \frac{\sigma^2}{(1 - r_{12}^2) \sum_{i=1}^{n} (x_{ik} - \bar{x}_k)^2}.
\]

If the two variables are perfectly correlated, the variance is infinite. When the variables are highly correlated, the following symptoms are observed:

- small changes in the data produce big changes in parameter estimates;
- while the \( R^2 \) is high, coefficients have low significance levels;
- coefficients have incorrect signs and magnitudes. (Green, p. 57)

There are methods for determining the degree of collinearity among the regressors. One is calculating a variance inflation factor (VIF), \((1 - R^2_k)^{-1}\) for each coefficient. Another measure is the condition number of \( XX \), which is the square root of the largest characteristic root of \( XX \) to the smallest. However, these methods say nothing about what degree is considered “dangerous” because of its effects on the variance of the estimates, and present no method for overcoming the problem. The level of collinearity which is dangerous depends on \( X \), the true \( b \) and the reason for which an econometric approach is undertaken. There is no general method for determining when multicollinearity is “bad”. A common “rule of thumb” is to be concerned when the variance inflation factor exceeds 10. It is also generally recognized that multicollinearity can be rectified with additional information in the form of
more data or prior knowledge about some of the parameters. When all the available data has been employed, the only way to deal with multicollinearity is dropping the variables suspected of causing the problem by imposing an assumption that the variable does not belong to the model (the coefficient is zero).

In our case, the variable that is causing multicollinearity in the production function estimation is the acreage itself, which obviously cannot be dropped from the equation.

The variance inflation factors for the regression above are

<table>
<thead>
<tr>
<th>Variable</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnLand</td>
<td>10.86</td>
</tr>
<tr>
<td>lnVC</td>
<td>7.63</td>
</tr>
<tr>
<td>lnhrs</td>
<td>2.64</td>
</tr>
<tr>
<td>lnseed1</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Mean VIF 5.88

which points at lnLand as a culprit, as VIF greater than 10 is usually frowned upon. Dropping lnLand from the regression results in

| lnYlbs | Coef. | Std. Err. | t  | P>|t|   | [95% Conf. Interval] |
|--------|-------|-----------|----|-------|----------------------|
| lnhrs  | 0.004262 | 0.0602334 | 0.07 | 0.944 | -0.11483 0.123354 |
| lnseed | 0.288594 | 0.070667  | 4.08 | 0     | 0.1488723 0.428315 |
| lnVC   | 0.772188 | 0.0696148 | 11.09| 0     | 0.6345467 0.909828 |
| _cons  | 2.238567 | 0.3803576 | 5.89| 0     | 1.486533 2.990602  |

with adjusted R-squared = 0.8425 and the VIF matrix being

<table>
<thead>
<tr>
<th>Variable</th>
<th>VIF</th>
<th>1/VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnVC</td>
<td>3.79</td>
<td>0.263735</td>
</tr>
<tr>
<td>lnseed</td>
<td>2.92</td>
<td>0.342947</td>
</tr>
<tr>
<td>lnhrs</td>
<td>2.46</td>
<td>0.406221</td>
</tr>
<tr>
<td>Mean VIF</td>
<td>3.06</td>
<td></td>
</tr>
</tbody>
</table>

An obvious way of dealing with multicollinearity caused by the acreage variable would be to estimate the per acre yield function assuming there are no economies of scale. Using the survey data, estimation of the function

$$\ln(Y/acre) = \ln(Labor/acre) + \ln(seed/acre) + \ln(other VC)$$

results in very bad fit with small parameter estimates with mostly wrong signs:

| lnYlbs_peracre | Coef. | Std. Err. | t  | P>|t|   | [95% Conf. Interval] |
|----------------|-------|-----------|----|-------|----------------------|
| lnhrs_peracre  | -0.1451| 0.0423379 | -3.43| 0.001 | -0.22878 -0.06141  |
| lnseed_peracre | -0.0848| 0.0383815 | -2.21| 0.029 | -0.16066 -0.00893  |
| lnVC_peracre   | 0.157136| 0.0706803 | 2.22| 0.028 | 0.0174308 0.29684  |
| _cons          | 7.663207| 0.4199123 | 18.25| 0     | 6.833219 8.493196  |

and VIF values of 1.01.

The lack of functional dependence between the inputs and the yields can be illustrated by the scatterplots for labor per acre and seed per acre below:
Clearly, while the total input use data is multicollinear, the per acre input data is much too noisy to be of any use, the reason being the above mentioned fact that some of the inputs are inverse proxies for the land quality.

The best fit obtained from estimation of the pooled sample data is from regressing the total output (in pounds) on acreage and total variable costs (ln(TVC)) that includes the cost of labor, seeds, fertilizer, chemicals, and materials:

\[
\begin{array}{lccccc}
\text{lnYlbs} & \text{Coef.} & \text{Std. Err.} & t & P>t & [95\% \text{ Conf. Interval}] \\
\text{lnLand} & 0.98421 & 0.0679922 & 14.48 & 0 & 0.8501932 - 1.118226 \\
\text{lnTVC} & 0.0952 & 0.0665086 & 1.54 & 0.125 & -0.02874 - 0.233445 \\
\text{cons} & 7.01497 & 0.398599 & 17.6 & 0 & 6.229308 - 7.800632 \\
\end{array}
\]

Number of obs = 218
Prob > F = 0.0000
R-squared = 0.9225
Adj R-squared = 0.92

Variance Inflation Factors: ln(Acreage) – 8.68; % of irrigated land – 1.1, ln(TVC) – 8.61.

The results, if acceptable, suggest mild economies of scale and an average pooled sample yield of 2,890 pounds per acre. Inserting the proportion of irrigated land variable in the regression improves the fit and shows a significant coefficient of 0.37. The increasing economies of scale indicate that production has to be constrained by something (quota in our case) and that calculating supply elasticity at the 2002 production level is impossible.

A possible way of reducing the data noise is using sub-samples grouped by the important characteristics that make the sub-samples more homogenous. The most important farm attribute in peanut production is land irrigation, which has been confirmed by the regional shifts in peanut production since 2002 – while acreage in the Southeast increased dramatically, it decreased in the Southwest, primarily because of limited availability of irrigated land that would provide profitable yields.

Unfortunately, regressing the yields on per acre input quantities for dry and irrigated land separately does not produce any satisfactory fit, showing too much noise in the data (just like in the case of estimating the pooled data).

Regressing production on irrigated land on irrigated acreage and corresponding values of per acre costs of fertilizer, chemicals, and seed input produces the following estimates:

\[
\begin{array}{lccccc}
\text{lnyirr} & \text{Coef.} & \text{Std. Err.} & t & P>t & [95\% \text{ Conf. Interval}] \\
\text{lnacreirrT} & 0.817 & 0.073668 & 11.09 & 0 & 0.668225 - 0.965775 \\
\end{array}
\]
The VIF values are all less than 2. Inclusion of labor and other variable costs results in VIF values higher than 30 and low significance.

Regressing production on dry land on dry acreage, per acre costs of fertilizer, chemicals, and seed input produces the following results:

| Variable | Coef.  | Std. Err. | t     | P>|t| | 95% Conf. Interval |
|----------|--------|-----------|-------|------|-------------------|
| lnacredryT | 0.963599 | 0.07528 | 12.8  | 0  | 0.814299 - 1.112899 |
| lnfertdry | -0.10187 | 0.060634 | -1.68 | 0.096 | -0.22212 - 0.018385 |
| lnchemdry | 0.135707 | 0.06323 | 2.15  | 0.034 | 0.010305 - 0.261108 |
| _cons    | 7.619249 | 0.31514 | 24.18 | 0  | 6.994244 - 8.244255 |

Number of obs 107
F( 3, 103) 193.14
Prob > F 0
R-squared 0.8491
Adj R-squared 0.8447
Root MSE 0.53089

The VIF values are all less than 3.5. Inclusion of labor and other variable costs results in VIF values higher than 30 and low significance.

A few differences between dry and irrigated production estimates are worth noting. The acreage coefficient in the irrigated production estimate is smaller than the one in dry land production, which shows diminishing marginal returns to land most likely due to higher management intensity of irrigated land production. As peanuts are a highly management intensive crop, limited endowment of operator’s own time accounts for diminishing per acre yields, particularly on irrigated land because it requires more managerial time/effort. However, higher productivity of irrigated land is reflected in the higher value of the constant term.

The coefficient at fertilizer is small and insignificant in both cases, which confirms the fact that peanut production does not require conventional fertilizers, as peanuts produce their own nitrogen. However, many farmers continue applying fertilizers, regardless of the advice from extension specialists. The chemicals coefficient is small and significant in both estimations, which is not surprising as chemicals, while being an important production input, are applied in smaller proportion to peanuts than to their alternatives, cotton and corn. Recent increases in chemical prices have allegedly contributed to the increase in peanut plantings in the Southeast.

Disregarding the insignificant variables, production on dry land shows slightly increasing returns to scale, while returns to scale in irrigated land production are nearly constant. Thus, there is little reason to believe that peanut acreage expansion by individual producers (few farmers in the Southeast do not plant peanuts) will be curbed by decreasing
However, the slight advantage in scale economies of the dry land production is not enough to compensate for the smaller dry land yields that, at current prices, render dryland peanut production unprofitable.

In modeling post-2002 peanut supply responses, it is more realistic to consider mainly estimates of the irrigated acreage production, unless prices rise high enough to make dry acreage production profitable. Currently, however, farmgate prices ($355 per ton plus the “option” premium) are too low to support profitable peanut production on dry acreage even in the Southeast, as industry practitioners estimate that in average, in order to break even at the $355 price, the yield should be no less than 3,600lbs per acre. In the Southeast in 2001, the average peanut yield from the dry land was 2770lbs/acre, and 3940 from the irrigated land.

Invoking the expression for supply price elasticity from the Methodology section,

$$\varepsilon_p = \frac{r}{1-r},$$

produces a tentative estimate of the irrigated land supply elasticity with respect to price of 4.46 and possibly higher. As to the dry land production supply elasticity, the estimated increasing returns to scale imply infinite output in unconstrained profit maximization, which make elasticity calculations irrelevant. In reality, though, the production on limited resources of dry land is unprofitable.

Comparing the irrigated production supply elasticity to the actual price and quantity changes that occurred in the last 3 years is not useful, as planting decisions have been driven by many other factors mentioned in the Industry Adjustment section. But, most importantly, the acreage expanded while the prices actually dropped (by about 35 percent) because peanut production before 2002 was suboptimal because of the quantity constraints imposed by the quota system. This suggests that, while the quota peanut production on irrigated land was more profitable in per acre terms, the total profits from expanded acreage with lower output prices might make up for the lost privileges.

These suggestions could be confirmed by estimating the peanut production cost function. Methodologically, the use of the cost function instead of the production function can be justified if the input prices are unknown but provided they vary substantially among the households in the representative sample, be it for locational or other reasons (Coelli, p. ??). In the absence of input price variation (i.e., when the sample is geographically concentrated), one can use cost shares per unit of input (cost shares per unit of output in this case would be equivalent to production function production function). Suppose we hypothesize a Cobb-Douglas cost function:

$$\ln C_i = \beta_0 + \beta_i \ln y + \sum_k \beta_k \ln w_{ik},$$

where $w_{ik}$ is the unit price of $k^{th}$ input faced by an $i^{th}$ household. $w_{ik}$ can be written as a ratio of the household’s expenditure on $k^{th}$ input to the quantity of input used: $w_{ik} = \frac{E_{ik}}{x_{ik}}$.

If we assume that the same amount of every input is applied to an acre planted with the crop ($\frac{A_{acreage}}{x_k} = a_k$), where A denotes acreage,
\[ \ln(w^i_k) = \ln\left(\frac{E^i_{w_k}}{x^i_k}\right) = \ln\left(\frac{A^i_k}{x^i_k}\right) + \ln\left(\frac{E^i_{w_k}}{A^i_k}\right) = a + \ln\left(\frac{E^i_{w_k}}{A^i_k}\right), \]

where \(\frac{E^i_{w_k}}{A^i_k}\) is the per acre expenditure on the \(i\)th input, and the cost function can be expressed in terms of per acre input expenditures:

\[ \ln C_i = \beta_0 + \sum_k \beta_k a_k + \beta_1 \ln y + \sum_k \beta_k \ln\left(\frac{E^i_{w_k}}{A^i_k}\right). \]

The table below provides some statistics on the variable costs:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (value of peanuts in $ per acre)</td>
<td>722</td>
<td>226</td>
<td>312</td>
<td>1514</td>
</tr>
<tr>
<td>Total Cost (value in $ per acre)</td>
<td>658</td>
<td>246</td>
<td>320</td>
<td>1812</td>
</tr>
<tr>
<td>Price of capital ($ per acre)</td>
<td>139</td>
<td>114</td>
<td>41</td>
<td>987</td>
</tr>
<tr>
<td>Cost of own labor per acre</td>
<td>126</td>
<td>13</td>
<td>2</td>
<td>126</td>
</tr>
<tr>
<td>Price of land ($ per acre)</td>
<td>51</td>
<td>20</td>
<td>21</td>
<td>134</td>
</tr>
<tr>
<td>Price of fertilizer ($ per acre)</td>
<td>40</td>
<td>31</td>
<td>0</td>
<td>135</td>
</tr>
<tr>
<td>Price of seeds ($ per acre)</td>
<td>64</td>
<td>38</td>
<td>7</td>
<td>131</td>
</tr>
<tr>
<td>Price of pesticide ($ per acre)</td>
<td>121</td>
<td>131</td>
<td>0</td>
<td>377</td>
</tr>
<tr>
<td>Price of paid labor per acre</td>
<td>56</td>
<td>9</td>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td>Price of materials ($ per acre)</td>
<td>61</td>
<td>38</td>
<td>15</td>
<td>184</td>
</tr>
</tbody>
</table>

The estimates of the cost function are as follows:

<table>
<thead>
<tr>
<th>Log_VC_per-acre</th>
<th>Coefficient</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log(Output per acre)</td>
<td>0.010</td>
<td>(0.138)</td>
</tr>
<tr>
<td>Log(price of labor)</td>
<td>0.355***</td>
<td>(0.056)</td>
</tr>
<tr>
<td>Log(price of seeds)</td>
<td>0.303***</td>
<td>(0.042)</td>
</tr>
<tr>
<td>Log(price of fertilizer)</td>
<td>0.043</td>
<td>(0.044)</td>
</tr>
<tr>
<td>Log(price of pesticide)</td>
<td>0.125***</td>
<td>(0.044)</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.467***</td>
<td>(0.912)</td>
</tr>
</tbody>
</table>

*** - significant at 5% level.

While most of the input price coefficients are significant and have correct signs (though they do not quite sum to one), output is not. This can be explained by a peculiarity of the quota system. Under this quota support program, the quota, i.e., the volume of peanuts to be produced for edible purposes, was tied to specific land tracts because of the original...
peanut quota allocation (allotments). Switching production to more fertile land would invalidate the quota. The quota tracts had vastly different qualities and peanut production potential – while some land was productive enough to bring high yields even without applying high volumes of agricultural inputs, other areas required more inputs but this still did not result in proportional yield increases. The inability of producers to allocate appropriate land to peanuts due to the quota constraints may be behind the observed lack of positive dependence between the yields and per acre costs in the estimation results. Evidence of massive reallocation of peanut acreage that took place after 2002 of nearly one-quarter peanut base acres confirms this argument. This, unfortunately, invalidates the use of cost function in the analysis.

Conclusions
In the current version of the paper, we make an attempt to estimate the supply of farmer stock peanuts in the Southeastern Region of the U.S. and evaluate production and welfare effects of the recent changes in farm support policies and of trade liberalization. The choice of estimation methodology is dictated by the unavailability of suitable time-series data due to heavily regulated nature of the U.S. peanut markets before 2002. Supply estimation is performed by first estimating farm-level supply using cross-sectional survey data on farm-level costs and returns and then aggregating the results into a regional supply function using aggregate data and industry facts. The objective is to find how vulnerable the U.S. peanut production has become after the 2002 Farm Act to trade liberalization and the increase of production by major peanut producing countries. Knowing this is important because gradual agricultural trade liberalization under the WTO and regional agreements increases competitive pressure on domestic producers, and peanut production is of vital importance to the rural communities, particularly the Southeast.

The data used in the analysis come from the 2002 Southeast peanut farm costs and returns survey. In the production function analysis, we mostly concern ourselves with variable inputs, and assume a Cobb-Douglas production function for the sake of its theoretical tractability.

Preliminary analysis reveals that there is a high degree of correlation between the total output and each of the variable inputs. However, estimation of the production function in its entirety is wrought with the issues of multicollinearity (the acreage variable). Besides, some inputs may actually be (imperfect) inverse proxies for the land quality/productivity, which varied greatly under the supply management policies because the peanut quota was assigned to specific land tracts more than half a century ago, since when the quality of some tracts had deteriorated. This suggestion is confirmed by inconsistent estimates of the yield function.

The consistency of production function estimates is improved by estimating the irrigated and dry land production separately. The importance of irrigation has been confirmed by the regional shifts in peanut production since 2002 – while acreage in the Southeast increased dramatically, it decreased in the Southwest, primarily because of limited availability of irrigated land that would provide profitable yields.

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4 Quota quantity restrictions were introduced later in order to curb the increase in harvested quota peanuts which resulted from the applications of technological innovations in agriculture.
The results show diminishing marginal returns to irrigated land most likely due to higher management intensity of irrigated land production. However, higher productivity of irrigated land is reflected in the higher value of the constant term. The significance of fertilizer input is insignificant for both land types, confirming the fact that peanut production does not require conventional fertilizers, as peanuts produce their own nitrogen. The chemicals coefficient is small and significant in both estimations, which is not surprising because chemicals, while being an important production input, are applied in smaller proportion to peanuts than to their alternatives, cotton and corn (recent increases in chemical prices have allegedly contributed to the increase in peanut plantings in the Southeast).

Production on dry land shows slightly increasing returns to scale, while returns to scale in irrigated land production are nearly constant. Thus, there is little reason to believe that peanut acreage expansion by individual producers (few farmers in the Southeast do not plant peanuts) will be curbed by decreasing (land) productivity. However, the slight advantage in scale economies of the dry land production is not enough to compensate for the smaller dry land yields that, at current prices, render dryland peanut production unprofitable.

In modeling post-2002 peanut supply responses, it is more realistic to consider the estimates of the irrigated acreage production, unless prices rise high enough to make dry acreage production profitable. Currently, farmgate prices ($355 per ton plus the “option” premium) are too low to support profitable peanut production on dry acreage even in the Southeast, as industry practitioners estimate that in average, in order to break even at the $355 price, the yield should be no less than 3,600lb per acre. In the Southeast in 2001, the average peanut yield from the dry land was 2770lbs/acre, and 3940 from the irrigated land.

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The general conclusion is that producers not able to expand peanut acreage are likely to be vulnerable to price reductions, as there might exist economies of scale. Production on dry land is likely to remain unprofitable at the current price levels. However, the analysis is complicated by severe multicollinearity problems and noisiness of the input data explained by the fact that many input variables may be inverse proxies for land productivity, which varied because of the constraints imposed by the supply management policies.
Bibliography:


