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Productivity and Technical Change in Brazilian Agriculture

Carlos A. Arnade

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Abstract

Brazil's agricultural sector underwent major changes in the past two decades. Though Brazil is abundant in labor, land, and animal power, government subsidies encouraged the use of fertilizer and machines. Since productivity growth arises from technical change, Brazil's drive to modernize its agricultural sector should improve agricultural productivity. However, inefficient production practices arising from subsidies can slow multifactor productivity growth. Recent removal of agricultural subsidies in Brazil has coincided with increased productivity, providing evidence that input subsidies made Brazilian agriculture inefficient.

Keywords: Productivity, Brazil, input subsidies, efficiency, technical change, cost function.

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Summary

This report discusses Brazil's modernization drive in the context of induced innovation models. Government subsidies of agricultural inputs may induce producers to adopt inefficient producer practices when created and, surprisingly, may induce further inefficiencies when removed. Estimates of a cost function for Brazilian agriculture are used to identify and divide the sources of multifactor productivity growth. In the 1970's, productivity growth from technical change was offset by a decline in the efficiency of agricultural production. However, agricultural efficiency rose when subsidies declined dramatically for a short period in the early 1980's.

Brazil's agricultural modernization represents active government promotion of technical change. Brazil's subsidies for use of agricultural machinery in the 1950's and 1960's led to a rapid expansion in the use of tractors. Fertilizer subsidies in the 1970's led to a rapid expansion in the use of fertilizer and high-yield varieties of seed.

Brazil's drive to change its agricultural technology appears, at first, to be a modest success. Labor productivity grew 5.3 percent per year from 1968 to 1987, while land productivity grew 2.8 percent per year. Brazil captured a significant share of the world soymeal and citrus markets during this period.

However, Brazil's subsidies encouraged the use of factors that often substitute for Brazil's abundant factors, such as land, labor, and animal power. The Government's modernization drive may have encouraged overutilization of relatively scarce factors of production and thus reduced the efficiency of the agricultural sector.

Productivity and Technical Change in Brazilian Agriculture

Carlos A. Arnade

Introduction

Brazil's agricultural modernization represents active government promotion of technical change. Agricultural subsidies (including credit) make up a significant percent of Brazil's government expenditures (16, 28).[1] The government commitment to costly input subsidies in the face of inflation and labor displacement demonstrates the high priority given to modernizing the agricultural sector.

The Brazilian Government, in the early 1950's, began subsidizing the production and use of agricultural machinery. The use of agricultural machinery grew rapidly for the next 20 years. The number of tractors grew from 8,375 in 1950 to 165,870 in 1970 (34). Government subsidies of commercial agricultural inputs expanded in the 1970's. Preferential interest rates were given to users of fertilizer, machinery, and other production inputs while agricultural research stations disseminated high-yield varieties of seed.

Brazil's drive to change its agricultural technology could be considered a modest success. From 1968 to 1987, the ratio of the number of mules and asses used in agriculture to the number of tractors, an indicator of the relative use of traditional versus modern technology, fell from 61 to 4.8. Labor productivity grew 5.3 percent per year from 1968 to 1987 while land productivity grew 2.8 percent per year. Meanwhile, the nominal value of agricultural production rose from $4.7 billion in 1970 to $23 billion in 1985 (39). During this period, Brazil developed soybean and citrus varieties adapted to local growing conditions and captured a significant share of the world soymeal and citrus markets.

Despite these statistics, Brazil's mechanization of its agricultural sector was not an unqualified improvement. Brazil has abundant land, labor, and animal resources. Brazil's subsidies encouraged the use of fertilizer, machines, and seed, which often substitute for land, labor, and animal power. If abundant resources are relatively low-priced, then the Brazilian Government's modernization drive may have encouraged overutilization of relatively scarce factors of production and thus reduced the efficiency of the agricultural sector.

[1] Underscored numbers in parentheses refer to sources listed in the References section.

Since productivity growth is generally thought to arise from technical change, Brazil's drive to modernize its agricultural sector should be expected to improve Brazil's agricultural productivity.[2] However, inefficient production practices can slow multifactor productivity growth.[3] Estimates of a cost function for Brazilian agriculture are used to identify and divide the sources of multifactor productivity growth. Productivity growth from technical change in the 1970's was offset by a decline in the efficiency of agricultural production. However, efficiency rose when subsidies declined dramatically for a short period in the 1980's and then fell again as implicit subsidies, caused by inflation, increased.

Brazil's Agricultural Growth

Figure 1 presents indices of aggregate output of Brazilian crops and aggregate inputs used in these crops.[4] The indices are provided in appendix table 1. Output and input indices are normalized to equal 1 in the base period (1968) to provide a clear view of relative changes in output and input indices. A multifactor productivity index, which represents the ratio of the aggregate output index to the aggregate input index, is presented in figure 2. Figure 3 presents an index of credit subsidies for machines and fertilizers, relative to total crop revenues. Calculation of indices is described in a companion report (2).

Brazilian outputs and inputs grew at similar rates from 1968 to 1978 so multifactor productivity stagnated. Input growth slowed in the late 1970's and early 1980's while output continued to grow, leading to productivity gains.

The level of input use roughly follows the subsidy index. Brazil's agricultural input subsidies dropped dramatically in 1980/81 as the Brazilian Government changed the interest rate on agricultural credit from 0 to 45 percent. Subsidies stayed low for 4 years and climbed again as government-controlled agricultural interest rates failed to keep up with growing inflation. The fall in subsidies coincided with stagnation of input use, while the second round of growing credit subsidies coincided with a rise in input use.

Technical Innovation in Brazilian Agriculture

The rapid growth of both outputs and inputs in Brazilian agriculture reflects producer adoption of higher yielding, input-intensive production technology. Ahmad (1) introduced an innovation

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[2] Multifactor productivity is often considered a useful measure of competitiveness (2).

[3] Multifactor productivity represents the ratio of output to an index of a weighted sum of all the inputs used in production. See Arnade (2), Ball and Harper (3), Capalbo and others (8), and Chambers (11).

[4] The indices (fig. 1) depict a Tornqvist output index, representing an aggregate index of 54 Brazilian crops, and a Tornqvist input index representing a broad number of inputs. Outputs represent a weighted sum of individual outputs and inputs a weighted sum of individual inputs. Revenue shares serve as weights on outputs. The ratio of the input expenditures to revenues serves as input weights (2,3,8,11).

Figure 1
Aggregate agricultural indices

1968 = 1

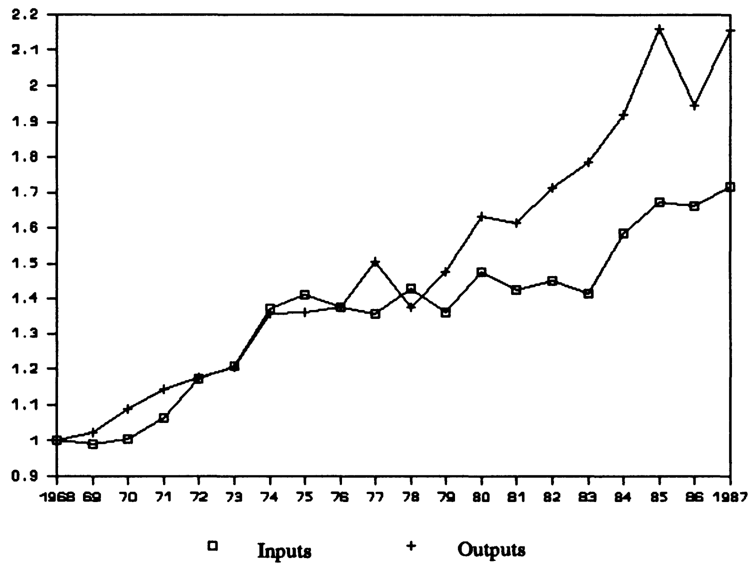


Figure 2
Crop productivity: Brazil

1968 = 1

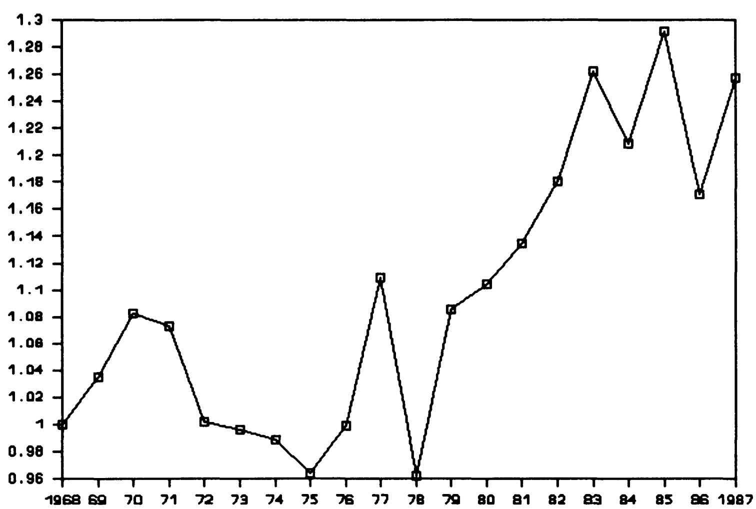
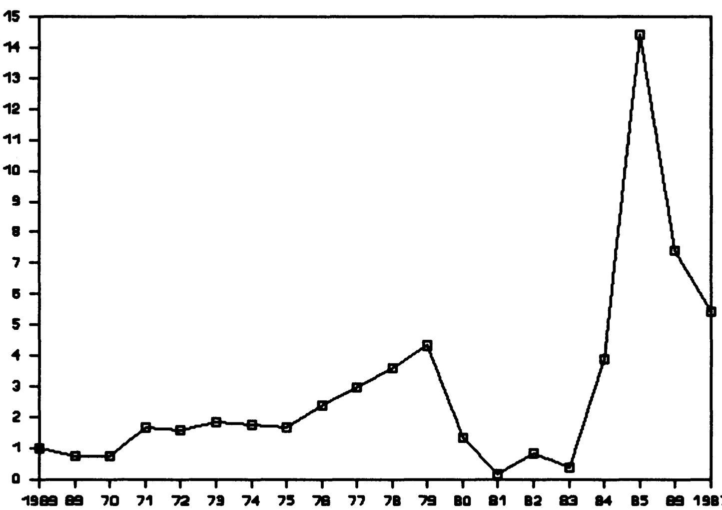


Figure 3
Index of input subsidy

1968 = 1



possibilities curve (IPC), which has become a basic component of many technical change models (6, 13, 18, 34) and can illustrate certain effects of Brazil's modernization drive. Ahmad's IPC is a hypothetical isoquant giving the efficient combinations of inputs using all possible technologies that could produce a given output. Tangent to Ahmad's IPC are isoquants representing actual technologies.

For example, in figure 4 there are two inputs: land (X1) and modern inputs (X2). The isoquant T1 represents a technology that uses more land than the other technology represented by the isoquant T2. Along either isoquant are listed the possible tradeoffs between land and other inputs. The IPC is an inner envelope of these and other technologically possible input combinations. Once a new technology is adopted, producer choices are limited to the input combinations along the isoquant representing the adopted technology.

Relative input prices drive innovation and adoption in Ahmad's model. Technologically efficient possibilities are represented by IPC_0 in time period 0 and represented by IPC_1 in the next time period (1). The cost line (CO) representing one set of relative input prices is tangent to the IPC_1 at point A while the cost line (C1) representing a second set of relative input prices is tangent to the IPC_1 at point B. Research institutions and farmers will choose technology T1 if CO is the relevant cost line and will choose T2 if C1 is the relevant cost line.

Induced innovation models have many shortcomings. Both private and public research institutions may not respond to the same price signals, if they respond at all. Furthermore, much technological innovation is a random process. For example, the sugar substitute, Nutrasweet, was discovered in the middle of a medical experiment. Finally, an aggregate of researchers and producers may not be price takers for the technology they jointly choose to produce and adopt.[5] Technology developed in response to one budget line may not be optimal once the impact of technology on input prices is felt.

The Past

Brazil's modernization drive appears contrary to the induced innovation hypothesis. If relatively abundant factors have relatively low prices, then one would expect Brazil to adopt a land-intensive, animal-intensive, and labor-intensive technology. Instead, Brazil's modernization drive increased the use of agricultural chemicals and machinery relative to land, labor, and animal power. To encourage development and adoption of new agricultural technology, the Brazilian Government made credit available at reduced interest rates for specific purposes like machine or fertilizer use.

In figure 4, let the input on the horizontal axis (X1) be an abundant input (land, labor, animal power) and the input on the vertical axis (X2) be a scarce input. Line CO represents Brazil's budget line without subsidies and line C1 represents Brazil's budget line with subsidies. Given the presence of these subsidies, researchers and producers behaved rationally in developing and adopting technology that makes intensive use of scarce inputs (T2) rather than abundant inputs (T1).

The Present: Technically Trapped

Once subsidies encourage producers to adopt a technology intensive in the use of relatively scarce factors of production, producers may then become trapped into using that technology.[6] Suppose producers are at point B using technology T2 and subsidies on modern inputs are removed. Line CO then becomes the relevant cost line. If producers are able to switch technologies, producers will drop technology T2 for technology T1 and move to point A. However, it may not be possible to switch to T1. Researchers may lack funds to develop technology T1 or producers may be unable to bear adjustment costs associated with adopting technology T1. For example, there may be no market for a tractor on which a producer is making payments so adjusting to the new technology requires throwing away an existing asset.[7]

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[5] The distinction between technical change and technical adoption is not emphasized enough. Economists often accept a lag between technology change and its effect on input demand. Yet, this is not enough of a distinction between technical change and technical adoption. Some developed technology is never used. Some adopted technology is developed for other purposes. For example, augers, which are now used for moving grain into and out of storage facilities, were developed for the mining industry.

[6] This may be only a shortrun phenomenon. However, even in the United States, producers do not give up existing assets easily. Johnson and Quance (29) point out that if, at the margin, an asset's value in use on the farm is less than its acquisition cost but greater than its salvage value, farm assets can become trapped in current uses. In Brazil, removal of machinery subsidies could make the acquisition cost of new machinery high while keeping salvage values low because the machinery is not optimal in the post-subsidy world and because past subsidies have made machinery plentiful. This situation could persist for years. Producers could then be trapped using specific levels of variable factors, such as energy, that complement the machinery.

[7] In another example, suppose relative fertilizer prices rise to the point that it is optimal to grow lower yielding varieties of crops that use little fertilizer. If no other seeds are available and producers are forced to maintain their fertilizer use or accept lower yields, then these producers are technically trapped.

When subsidies are removed and CO becomes the cost line, technically trapped producers move to point D on the T2 isoquant. Point D represents the optimal point for producers who are locked into using the technology represented by T2. This point is tangent to the cost line C2, which is higher and parallel to CO. The higher per unit costs at point D reveal the true cost of the inefficiency created by the subsidies. However, removal of input subsidies can create even greater inefficiencies than the subsidies themselves.

Faire and others (17) divide inefficiency into two components. A technically inefficient point represents an optimal input mix given a set of relative input prices, but uses more inputs than would be represented by an isoquant. For example, point P (fig. 5) is technically inefficient because it lies inside the isoquant Yo. In contrast, an allocatively inefficient point, PP, lies on the correct isoquant, but, given a set of relative input prices, does not represent the optimal input mix. Only point A is both technically and allocatively efficient.

Figure 4
Subsidy-induced innovation model

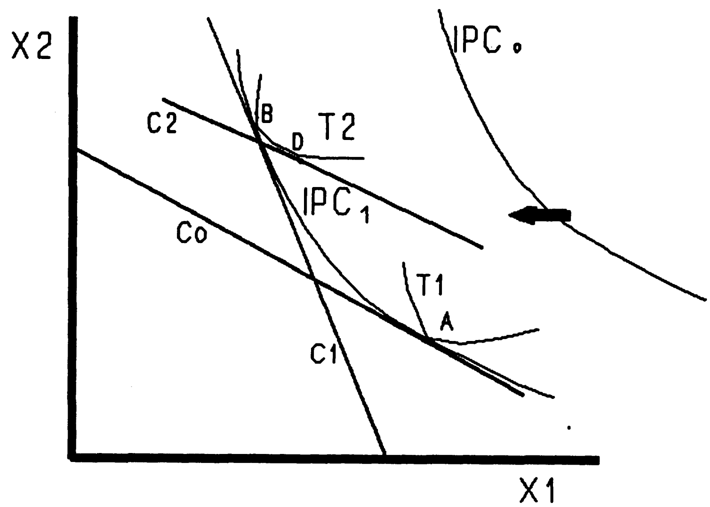
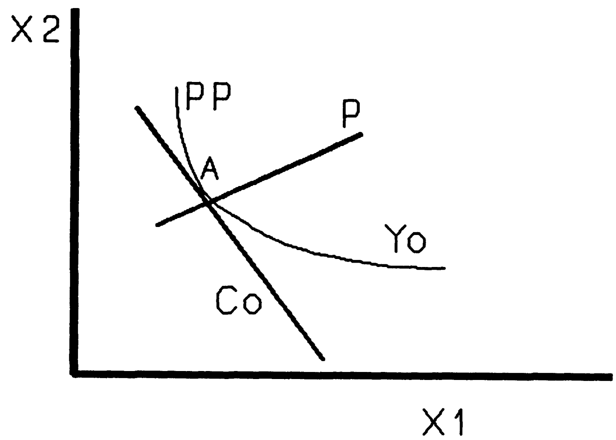


Figure 5
Allocative and technical inefficiency



In figure 4, if the budget line CO represents the true scarcity of inputs, point A is both allocatively and technically efficient relative to the IPC (instead of relative to a particular isoquant). Point B is technically efficient, because it remains on the IPC, but is allocatively inefficient relative to the IPC because it does not represent the optimal input mix along the IPC when the cost line is CO. Point D is both allocatively and technically inefficient relative to the IPC curve because it does not represent the optimal input mix and lies inside the IPC.

When subsidies are removed, and Brazilian producers move from point B to point A, they move from a point that is allocatively inefficient relative to the IPC to a point with no inefficiencies. On the other hand, if Brazilian producers move to point D, they move from a point that is allocatively inefficient to a point that is both allocatively and technically inefficient relative to the IPC.[8] Subsidies, which create one inefficiency when implemented, could create a second inefficiency when removed.[9]

Empirical Implications

The IPC models demonstrate that Brazilian producers could have remained trapped using technology that was no longer optimal after subsidies were removed. Also, removal of subsidies added an additional source of inefficiency to Brazilian agriculture if producers were trapped in using technology that was not optimal. This report uses two imperfect, but quite distinct, tests to determine if these two propositions hold.

The Elasticity of Substitution Test

The elasticity of substitution along the IPC frontier must be higher than the elasticity of substitution along an individual isoquant. When subsidies are removed, if producers move off the isoquant labeled T2 (fig. 4) and along the IPC frontier to point A, the point with no inefficiencies, then there should be a significant rise in the elasticity of substitution. If, instead, producers are trapped among the inefficient points along isoquant T2, then changes in the elasticity of substitution should be of a lesser magnitude.

A cost function is estimated over the period of subsidies and over a more general time period. Under both periods, statistical procedures are used to test the deviation from a zero elasticity of

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[8] However, point D is technically and allocatively efficient relative to isoquant T2.

[9] Reviewers emphasized that this second inefficiency must be a shortrun phenomenon, and in the long run all factors of production must optimally adjust. The question arises over how long is the short run. As long as an asset's returns lie between the cost of acquisition and the salvage value, producers can stay trapped using a particular technology. Brazil's inflation provides yet another reason for being trapped with inappropriate technology. Acquisition costs of new assets are rising due to inflation. However, salvage values of existing assets could be rising enough to make it profitable to hold onto an asset but not enough to keep up with acquisition prices of new technology.

substitution.[10] If the significance level of the test rises by a considerable amount over the more general period, producers could be viewed as moving along a broader isoquant over the more general period than in the period with subsidies. Also, dummy variables are used to determine if the elasticity of substitution changes significantly after subsidies are removed.[11]

This test is imperfect because it is difficult to judge what is a significant enough rise in the elasticity of substitution to indicate that producers are moving off an isoquant and onto a generally less curved frontier. If individual isoquants do not represent CES technology, movement along an isoquant will lead to some change in the elasticity of substitution.

The Efficiency Test

Consider a multifactor measure of Brazil's agricultural productivity taken over the subsidy and post-subsidy time periods. Multifactor productivity is associated with three sources of change: a change in technology, a change in output that creates an economies-of-scale effect, and a change in the efficiency of the production process.

Suppose the impact of technology and scale on productivity can be subtracted out so that the remaining term is an efficiency index. When subsidies are removed, if producers stay within existing technology and move to point D (fig. 4), the growth rate of an efficiency index should slow or even fall. In contrast, if producers move along the IPC to point A (which is a move to a point efficient in both the technical and allocative sense, relative to the IPC frontier), the efficiency index should rise. The efficiency test gives some indication if Brazilian producers are technically trapped or if, instead, Brazilian producers can adopt new technologies appropriate for the new relative factor price ratio.

When subsidies are removed, producers could move to an intermediate isoquant between T2 and the optimal isoquant. There is a possibility that the intermediate point could be closer to the new optimal point but overall efficiency could fall. At points closer to the optimal point, the gains in allocative efficiency from moving to an intermediate isoquant do not necessarily offset the loss in technical efficiency arising from not being on the IPC.[12]

Despite their imperfections, the combination of both tests provides a powerful tool to test the effect of Brazilian subsidies on Brazilian producers. If the elasticity of substitution fails to rise over the general period and efficiency falls after subsidies are removed, there would be a strong indication that subsidies trapped Brazilian producers into using inappropriate technology.

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[10] A cost function representing constant elasticity of substitution (CES) technology is nested within the Generalized Leontief (GL) cost function used in the next section. The ideal experiment is to test if the nested CES cost function is appropriate only during the subsidy period. This is what was tested. However, the cost function nested within a GL cost function represents a production function with a substitution elasticity of zero. Performing the ideal test is equivalent to testing deviation from a fixed-proportions production function.

[11] Brazil's agricultural input subsidies dropped dramatically in 1980/81 as the Brazilian Government changed the interest rate on agricultural credit from 0 to 45 percent. Subsidies stayed low for 4 years and climbed again as inflation took off in the mid-1980's.

[12] One can construct enough examples to show this is a possible but unlikely case.

The following Generalized Leontief cost function was specified:[13]

$$C = Z_1 * Y + Z_2 * Y^2 + \sum_i^I \alpha_i * W_i T + \sum_i^I \sum_k^K * \Gamma_{ik} * W_i * V_k \tag{1}$$

where:

$$Z_1 = \sum_i^I \sum_j^I (\beta_{ij} + \gamma_{ij} * D) * (W_i)^{1/2} (W_j)^{1/2} \tag{2}$$

and

$$Z_2 = \sum_i^I \lambda_i * (W_i) \tag{3}$$

where Y is a crop output index, T is the technology variable represented by the ratio of tractors to mules and asses, W_i are the prices of variable inputs, V_k are the quantities of inputs that are fixed in the short run, and the β_{ij}'s, α_i's, and other Greek letters represent parameters of the cost function. D's are dummy variables for 4 years between 1980 and 1984. Dummy variables were used to calculate if there were changes in cross-price elasticities, and hence elasticities of substitution. An increase in substitution elasticities when subsidies were removed would provide some indication that producers were moving off an individual isoquant and onto a more general IPC frontier.

Fixed inputs were machines and land. Variable inputs were seed, labor, energy, and chemicals. Fertilizer and pesticides were combined into one Tornqvist chemical index to save degrees of freedom and to avoid the problem of negative fertilizer prices.[14]

The above Generalized Leontief function is homogenous of degree 1 in prices. It is concave in prices if its matrix of second derivatives with respect to prices is negative semi-definite. Using Shepard's lemma, input demands can be written as:

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[13] The elasticity of scale equals the marginal cost over average cost and can be calculated from an estimated cost function.

[14] When subsidies are included, fertilizer prices for some years turn negative. However, a Tornqvist chemical index that combines fertilizer and pesticides has consistently positive prices.

$$X_i=\frac{\delta C}{\delta W_i}=Y*(\beta_{ii}+\sum_{j}^{J}(\beta_{ij}+\gamma_{ij}D)*(\frac{W_j}{W_i})^{1/2})+\sum_{i}^{I}\alpha_i T+\sum_{k}^{K}\Gamma_{ik}*V+\lambda_i*Y^2 \tag{4}$$

To obtain the estimators for the parameters of the cost function, we estimated the input demand equations from 1968 to 1987. The dummy variable was set equal to one for 4 years (1980-83) when input subsidies fell. Symmetry was imposed by setting $\beta_{ij}=\beta_{ji}$ and $\tau_{ij}=\tau_{ji}$. Both sides of the input demands were divided by output to eliminate a common source of heteroskedasticity.

Table 1 provides estimators of the above cost function whose Hessian at the mean data points was negative semi-definite. Chi-square statistics report the impact (on the variance/covariance matrix of errors) of imposing the restriction that estimators on the dummy variables equal zero. These statistics are significant at the 95-percent confidence level for all but seeds. Therefore, forcing the estimators on all dummy variables in each equation to be zero significantly alters the variance/covariance matrix of errors. The implication of this result is that cross-price effects (elasticities and elasticities of substitution) change significantly from the high- to low-subsidy period.

Table 1 also presents chi-square statistics that report the effect (on the variance/covariance matrix of errors) of imposing the restriction that estimators on the β_{ij}'s equal zero. For example, the three statistics on the right side of the seed equations jointly test if all substitution relationships with seeds are fixed proportions. This test was possible because the cost function representing a fixed-proportions production function is nested within the Generalized Leontief function.

Chi-square statistics for a model estimated from 1968-79 are significant in most cases. However, chi-square statistics representing the model estimated over the whole period are extremely high. These chi-square statistics in table 1 provide a clear demonstration that the isoquant over the more general period lies further from a fixed-proportion isoquant than the isoquant over the subsidy period. Therefore, substitution possibilities appear to be greater over the more general period.

Table 2 presents elasticities of input demand. Average elasticities of the variables and inputs are listed for the time period when the dummy variable equaled zero and the 4 years when the dummy variable equaled one. Elasticities on the quasi-fixed inputs are averaged for the whole period. With the exception of energy, own-price and cross-price elasticities tend to be low. The low own-price elasticity of demand for labor may reflect the large number of owner-operators who use their own and family labor.

Table 3 reports Morishima elasticities of substitution. These substitution elasticities are asymmetric so they are reported in both directions (11). Elasticities of substitution were calculated using average data from the periods when the dummy variable equaled zero and again from the periods when the dummy variable equaled one.

Table 1--Estimated paramaters of Generalized Leontief cost function

Parameter	Estimate	T-statistic	Chi-square statistic	Deviation from fixed proportions 1968-79	1978-87	1968-87
Seeds:						
ß11	3.72	4.25		17.8*	1,395*	28.87*
ß12 (chemicals)[1]	.098	.82				
τ12 (dummy)	-.122	-1.19				
ß13 (labor)	.111	2.92				
τ13 (dummy)	-.00001	-1.08				
ß14 (energy)	.068	.75	4.25			
τ14 (dummy)	.156	1.29				
Γ1L (land)	-2.52	-4.02				
Γ1M (machines)	.256	2.86				
λ1Y (output)	-1.44	-3.39				
α1T (technology)	.029	1.38				
Chemicals:						
ß22	-6.44	4.17		5.87	279*	23.5*
ß21 (seed)	.098	.82				
τ21 (dummy)	-.122	-1.19				
ß23 (labor)	.055	1.78				
τ23 (dummy)	.031	1.20				
ß24 (energy)	-.29	-3.28	14.25*			
τ24 (dummy)	.357	2.37				
Γ2L (land)	2.08	1.89				
Γ2M (machines)	4.16	23.84				
λ2Y (output)	1.35	2.84				
α2T (technology)	-.173	-5.40				
Labor:						
ß33	.99	6.64		16.5*	2,088.5*	22.9*
ß31 (seeds)	.111	2.92				
τ31 (dummy)	-.00001	-1.08				
ß32 (chemicals)	.055	1.78				
τ32 (dummy)	.031	1.20				
ß34 (labor)	.088	3.09	9.07*			
τ34 (dummy)	-.075	-2.83				
Γ3L (land)	.167	1.63				
Γ3M (machines)	.101	6.60				
λ3Y (output)	-.279	-6.60				
α3T (technology)	-.0126	-4.16				
Energy:						
ß44	2.23	1.65		4.23	1,971.5*	31.3*
ß41 (seeds)	.068	.74				
τ41 (dummy)	.156	1.29				
ß42 (chemicals)	-.29	-3.28				
τ42 (dummy)	.35	2.37				
ß43 (labor)	.088	3.09	8.6*			
τ43 (dummy)	-.075	-2.83				
Γ4L (land)	-.37	-.43				
Γ4M (machines)	-.69	-5.29				
λ4Y (output)	-.66	-1.36				
α4T (technology)	.059	2.01				

[1] Refers to the impact of the price of chemicals on the demand for seeds.
* Significant at the 1-percent confidence level.

Table 2--Elasticities of input demand[1]

Item	Seed	Chemical	Labor	Energy
		Dummy variable = 0		
With respect to prices:				
Seed	-0.310	0.0430	0.016	0.073
Chemical	.03	-.08	.005	-.21
Labor	.26	.108	-.03	.43
Energy	.015	-.06	.006	-.30
		Dummy variable = 1		
Seed	-.35	-.006	.02	.221
Chemical	-.011	-.11	.01	.05
Labor	.30	.10	-.15	.07
Energy	.07	.008	.001	-.32
With respect to the quasi-fixed inputs:				
Land	-2.24	-.89	.23	-.29
Machines	.22	2.70	.21	-.83
Technology	.33	-.98	-.22	.50

[1] Calculated from estimators of the cost function.

Table 3--Morishima elasticities of substitution

Item	D=0	D=1[1]	Change
			Percent
Seed/chemical	0.12	0.099	-17
Seed/labor[2]	.29	.45	55
Seed/energy	.32	.39	22
Chemical/labor	.14	.23	67
Chemical/energy	.24	.33	37
Labor/energy	.73	.39	-47
Chemical/seed	.35	.35	0
Labor/seed	.33	.37	13
Energy/seed	.38	.58	51
Labor/chemical	.08	.11	29
Energy/chemical	-.12	.16	233
Energy/labor	.46	.22	-52

[1] D=1 represents the 4 years when input subsidies fell.
[2] For example, the elasticity of substitution of labor for seed is 55 percent higher in the more general period.

Substitution elasticities between periods seem to change significantly. The elasticities between labor and seed and energy and seed rise significantly when subsidies are removed. Substitution elasticities between chemicals and energy and chemicals and labor also rise significantly. Chemicals and energy are recorded as complements in the subsidy period and as substitutes in the nonsubsidy period.

In contrast, substitution elasticities between seed and chemicals change little between periods. The elasticities between labor and energy fall in the period of low subsidies. This latter result could reflect a reduction in the use of machinery that increases the flexibility between using labor or energy.

On balance, these results provide evidence that substitution elasticities change significantly from the period with high subsidies to the period with low subsidies. This outcome suggests that producers may have the ability to move along a frontier broader than an individual isoquant.

Dividing Productivity

A changing elasticity of substitution does not guarantee that producers move off an isoquant and onto an IPC frontier. The efficiency test is another way to determine if producers are trapped within an isoquant such as T2 (fig. 4) and cannot move to the optimal technology when subsidies are changed. Given the argument made earlier, a decline in efficiency over the 4 years subsidies were removed would be an additional indication that producers are unable to move toward the optimal technology.

To obtain an efficiency index, productivity growth was broken into three components: (1) direct productivity growth due to a change in technology, (2) productivity growth due to the effect of technology on output and the effect of scale on productivity, and (3) a residual that serves as a proxy variable for efficiency.

Capalbo (9) used relationships established by Denny and others (15) and Ohta (33) to demonstrate that estimates of a cost function can help divide multifactor productivity growth. By differentiating a cost function and a budget line, and by using the relationship between the rate of cost diminution with respect to technology and the shift in a production function with respect to technical change (appendix), Capalbo showed that:

$$T\hat{F}P = -\hat{G}_t + (1-\epsilon_{cy}) * \hat{Y} + \mu \qquad (5)$$

where $T\hat{F}P$ is the rate of change in total factor productivity, $\hat{G}_t$ is the rate of cost diminution with respect to technical change, $\hat{Y}$ is the rate of change in output with respect to technology, and ϵ_{cy} is the elasticity of the cost function with respect to output.

$\hat{G}_t$ measures the direct effect of technology on productivity growth. The second effect is a scale effect that equals zero if the production function is constant returns to scale. The parameters required for calculating $\hat{G}_t$ and ϵ can be estimated from a cost function.

Capalbo calls $\hat{G}_t$ the direct technology effect, $(1-\epsilon_{cy})\hat{Y}$ the scale effect, and μ the residual effect, which serves as a measure of efficiency (appendix).[15] Estimates of the cost function can be used to calculate $\hat{G}_t$ and $(1-\epsilon_{cy})\hat{Y}$. The difference between the sum of these two terms and the growth of a Tornqvist index of total factor productivity represents an estimate of μ.[16] Productivity growth was divided into these component sources in each of four separate periods (table 4).

The residual effect from 1968 to 1979, a proxy for efficiency, offset the impact of technical change and economies of scale on productivity. From 1980 to 1983, when subsidies were low, the residual effect was positive, indicating a rise in efficiency. The residual effect turned negative after 1984 when subsidies expanded for a second time.

Efficiency fell during the period of subsidies but rose when they were briefly removed. This demonstrates that as machine and fertilizer subsidies fell in the early 1980's, the agricultural sector moved closer to the optimal technology, and allocative efficiency increased. However, the results show that as machine and fertilizer subsidies rose in the mid-1980's, some producers may have moved away from the optimal technology.

Table 4-- Division of productivity growth[1]

Item	1968-87	1968-79	1980-83	1984-87
			Percent	
Direct effect: $-\hat{G}^t$	0.8	0.8	0.7	0.75
Indirect effect: $(1-\epsilon_{cy})*\hat{Y}$	2.64	2.2	2.09	2.1
Residual	-2.3	-3.10	1.71	-2.65
Growth of $\hat{TFP}$ index	1.2	-.07	4.5	.2

[1] The direct and indirect effects were calculated from estimators of a cost function. The residual represents the differences between the sum of these two effects and the growth of the $\hat{TFP}$ index shown in figure 2.

[15] It is also well established that the elasticity of cost with respect to output is the inverse of the elasticity of scale of the production function.

[16] If cross-sectional data were available, they would provide a superior way to estimate efficiency.

The μ term contains statistical errors as well as the effect of efficiency on productivity. Since the expected value of the true error (or the sum of true errors across demand equations) is zero, the average of this residual can be considered an approximate estimate of the efficiency effect on productivity.

Estimates of μ will be biased since estimators obtained from an equation with missing variables will always be biased. These problems should not be a hindrance in completing the following exercise since: (1) no study has found an adequate measure of aggregate efficiency and thus all studies that estimate input demands have this bias; (2) the alternative is to do nothing to break down productivity; and (3) economists, in the past, have accepted biased estimators as a tradeoff for other statistical gains, as in ridge regression.

The hypothesis that agricultural subsidies reduced the efficiency of Brazil's agricultural sector is borne out by the efficiency test. However, empirical evidence from both the elasticity of substitution test and efficiency test does not support the second hypothesis that removal of subsidies left producers trapped in suboptimal technology and further reduced agricultural efficiency.

Why Subsidize the Use of Scarce Resources?

Technical change influenced Brazil's agricultural productivity primarily through a scale effect that developed when changing technology increased output (table 4). This result should be considered an unexpected windfall of this report and should be viewed in the context of arguments made by De Janvry and others (14). They emphasize that demand for technical change is not uniform and that the structure of a farm sector and government bias can influence the direction of technological change. They add "transaction costs" to standard input costs for land and labor.[17] They also argue that large landowners have high labor transaction costs and low land transaction costs while small landowners face high transaction costs on land and low transaction costs on labor.

Large landowners, then, demand labor-saving technology (such as machines) and small landowners demand land-saving technology (such as chemicals, fertilizer, and improved seeds). With different farmers demanding different technological change, the relative number, distribution, and political influence of large and small landowners become important determinants of technical change. De Janvry and others state, "When transaction costs are taken into account, the optimum technology becomes conditional on the distribution of assets and consequently there no longer exists a single optimum choice across firms" (14).

The results in table 4 indicate that scale effects of technical change on productivity growth overrode other effects. This reason alone would have encouraged large landowners to want subsidies for agricultural machinery. Thus, demands for technical change could vary between large and small landowners (even in the absence of transaction costs) without refuting the De Janvry hypothesis.

Agricultural policymakers could have been responding to demands of large landowners when machine subsidies were introduced in the 1950's and 1960's. In the 1970's, machines displaced labor, which migrated to the cities and made problems of rural unemployment more visible. Agricultural policymakers may have attempted to correct the policy bias toward large landowners by introducing fertilizer subsidies to encourage use of land-saving technology. On the other hand, fertilizer use complemented the new crop varieties in the 1970's, so the broadening of government incentives may have been only a continuation of policies to subsidize all new technologies.

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[17] Land transaction costs are the fixed costs of buying or selling land (titles, lawyers, licenses, search costs), and labor transaction costs are the cost of monitoring nonfamily labor.

Conclusions

Brazilian agriculture underwent widespread technical change over the past 20 years. This change had major consequences for Brazilian society. Aggregate productivity of Brazilian agriculture increased slightly as a result of adoption of new technology. Multifactor productivity grew little over the 1970's, but grew more quickly in the 1980's.

Dividing the growth in multifactor productivity shows that in the 1970's, productivity growth from technical change was offset by a decline in the efficiency of agricultural production. However, efficiency rose when subsidies declined dramatically for a short period in the 1980's and then fell again as implicit subsidies, caused by inflation, increased.

Adoption of new production technology generated output growth and apparently increased returns to scale. Large producers could be the primary beneficiaries of the new agricultural technologies. In any case, given the government policy, producers acted rationally in adopting technologies intensive in the use of Brazil's scarce factors.

The dampening effect of subsidies on agricultural efficiency, both when created and when removed, can apply anywhere. Efficiency and the elasticity of substitution rose immediately in Brazil upon removal of subsidies, indicating that Brazilian agriculture was not trapped using subsidized technology. However, the uniqueness of Brazilian agriculture should caution those who would relate this result to other economies and other industries.

References

1. Ahmad, S. "On the Theory of Induced Invention," Economic Journal, Vol. 76, 1966, pp. 344-57.

2. Arnade, C. Productivity of Brazilian Agriculture: Measurement and Uses. Staff Report No. AGES 9219, U.S. Dept. Agr., Econ. Res. Serv., July 1992.

3. Ball, E., and M. Harper. "Neoclassical Capital Measures Using Vintage Data: An Application to Breeding Livestock." Unpublished, U.S. Dept. Agr., Econ. Res. Serv., 1990.

4. Ball, V.E. Measuring Agricultural Productivity. Staff Report No. AGES 840330, U.S. Dept. Agr., Econ. Res. Serv., May 1985.

5. Banco Central do Brazil. Credit data, 1967-87.

6. Binswanger, H.P., and V.W. Ruttan. Induced Innovation: Technology, Institutions, and Development. Baltimore, MD: Johns Hopkins Univ. Press, 1978.

7. Bottomley, P., A. Ozanne, and C. Thirtle. "A Total Factor Productivity Index for UK Agriculture, 1967-1987," Discussion Paper, University of Reading, Department of Agricultural Economics & Management, Feb. 1990.

8. Capalbo, S., M. Denny, A. Hoque, and E. Overton. Methodologies for Comparisons of Agricultural Output, Input, and Productivity: A Review and Synthesis. Staff Report No. AGES 9122, U.S. Dept. Agr., Econ. Res. Serv., April 1991.

9. Capalbo, S. "Measuring the Components of Aggregate Productivity Growth," Western Journal of Agricultural Economics, Vol. 13, 1988, pp. 53-62.

10. Capalbo, S., T. Vo, and J. Wade. "An Econometric Data Base for Measuring Agricultural Productivity and Characterizing the Structure of U.S. Agriculture: Review and Synthesis." Working Paper, National Center for Food and Agricultural Policy: Resources For the Future, Washington, DC, 1986.

11. Chambers, R. Applied Production Analysis.. New York: Cambridge Univ. Press, 1988.

12. De Janvry, A. "A Socioeconomic Model of Induced Innovation for Argentine Agricultural Development," The Quarterly Journal of Economics, Vol. 87, 1973, pp. 410-435.

13. De Janvry, A. "Social Structure and Biased Technical Change in Argentine Agriculture," Induced Innovation: Technology, Institutions, and Development, Binswanger and Ruttan (Eds.). Baltimore, MD: Johns Hopkins Univ. Press, 1978, pp. 297-323.

14. De Janvry, A., E. Sadoulet, and M. Fafchamps. "Agrarian Structure, Technological Innovations, and the State," Economic Theory of Agrarian Institutions, P. Bardhen (Ed.). Oxford: Clarendon Press, 1989, pp. 357-382.

15. Denny, M., M. Fuss, and L. Wavermann. "The Measurement of Interpretation of Total Factor Productivity in Regulated Industries with Application to Canadian Telecommunications," Productivity Measurement in Regulated Industries, T. Cowing and R. Stevenson (Eds.). New York: Academic Press, 1981.

16. Elias, V. Government Expenditures On Agriculture and Agricultural Growth in Latin America. Washington, DC: International Food Policy Research Institute, 1985.

17. Faire, R., S. Grosskopf, and J. Logan. "The Relative Performance of Publicly-Owned and Privately-Owned Electric Utilities," Journal of Public Economics, Vol. 26, 1985.

18. Frisvold, G. Endogenous Technological Change in U.S. Agriculture: A Test of the Induced Innovation Hypothesis. TB-1790, U.S. Dept. Agr., Econ. Res. Serv., May 1991.

19. Fundacao Instituto Brasileiro de Geografia e Estatistica. Anuario Estatistico do Brasil (Annual Statistics of Brazil). Rio de Janeiro, Brazil. Various issues, 1964-89.

20. Getulio Vargas Foundation. Precios Pagos Pelos Agricultores (Prices Paid by Farmers). Rio de Janeiro, Brazil. Various issues, 1970-88.

21. ________. Precios Recebidos Pelos Agricultores (Prices Received by Farmers). Rio de Janeiro, Brazil. Various issues, 1970-88.

22. Getulio Vargas Foundation. Precios Medios do Boi Gordo e La (Average Prices of Beef and Wool). Rio de Janeiro, Brazil. Various issues, 1970-88.

23. ________. Salarios, Arrendamentos, Vendas de Terras Empreitadas (Salaries, Rents, and Sales of Land and Taskwork). Rio de Janeiro, Brazil. Various issues, 1970-88.

24. Getulio Vargas Foundation & Institute of Economics. "Projections of Supply and Demand for Agricultural Products of Brazil through 1975." Rio de Janeiro, Brazil. July 1968.

25. Instituto de Economia Agricola de Brazil. Prognostico. Various issues, 1970-89.

26. Inter-American Institute for Cooperation in Agriculture. Sistema De Informacio Para El Analisis Policia Agraria En America Latina y El Caribe. Staff Paper IICA, San Jose, Costa Rica, 1989.

27. International Monetary Fund. International Financial Statistics. Washington, DC. Various issues, 1970-89.

28. ________. Balance of Payments Statistics. Washington, DC. Various issues, 1975-87.

29. Johnson, S. L., and L. Quance. The Overproduction Trap in U.S. Agriculture. Baltimore, MD: Johns Hopkins Univ. Press, 1972.

30. Jorgenson, D., F. Gollop, and B. Fraumeni. Productivity and U.S. Economic Growth. Cambridge: Harvard Univ. Press, 1987.

31. Marshall, M. "The Modernization of Brazilian Agriculture: An Analysis of Unbalanced Development," Ph.D. dissertation, Purdue University, 1976.

32. Munhoz, D. Economia Agricola, Agricultura-Um Defesa dos Subsidos. R. Vozes (Ed.), 1982, p. 31.

33. Ohta, M. "A Note on Duality Between Production and Cost Functions: Rate of Return to Scale and Rate of Technological Progress." Economic Studies Quarterly, Vol. 25, 1974, pp. 63-5.

34. Sanders, J., and V. Ruttan. "Biased Choice of Technology in Brazilian Agriculture," Induced Innovation: Technology, Institutions, and Development. P. Binswanger and W. Ruttan (Eds.), Baltimore, MD: Johns Hopkins Univ. Press, 1978, pp. 276-96.

35. Santana, C. "The Impact of Economic Policies on the Soybean Sector of Brazil: An Effective Rate of Protection Analysis." Ph.D. dissertation, University of Minnesota, 1985.

36. United Nations Food and Agriculture Organization. Fertilizer Yearbook. Rome, Italy. Various issues, 1968-87.

37. ________. Production Yearbook, Rome, Italy. Various issues, 1968-87.

38. United Nations. Energy Statistics Yearbook. New York. Various issues, 1984-87.

39. Urban, Francis. World Agriculture: Trends and Indicators, 1970-1989. SB-815, U.S. Dept. Agr., Econ. Res. Serv., 1990.

40. U.S. Department of Agriculture, Foreign Agricultural Service. Commodity production, supply, and disposition database. Unpublished computer data.

41. Wilson, J. "Brazil's Orange Juice Industry," FAS-M-295, U.S. Dept. Agr., For. Agr. Serv., April 1980.

42. World Bank. Brazil Agricultural Sector Review: Policies and Prospects. Report No. 7798-BR, Washington, DC, 1990.

43. _________. World Tables. Baltimore, MD: Johns Hopkins Univ. Press, 1990.

Appendix: Dividing Productivity Growth

This report adapted Capalpo's approach by using cost relationships to identify the sources of productivity growth and divide it into component parts. To understand how cost diminution is related to productivity growth, first write productivity as a production function over the aggregate input:

$$TFP = Y/X = F(t, x_1(t), \dots x_i(t))/X(t) \qquad (1)$$

where x_i are individual inputs, t represents technology, and X is the Tornqvist index of the aggregate input. Logging equation 1 and differentiating productivity with respect to technology gets:

$$\frac{\delta LnTFP}{\delta Lnt} = \frac{\delta LnF(.)}{\delta Lnt} + \frac{\delta LnF}{\delta Lnx_i} * \frac{\Sigma \delta Lnx_i}{\delta Lnt} - \frac{\delta LnX}{\delta Lnt} \qquad (2)$$

The elasticity of scale ϵ equals the sum of the elasticities of output with respect to each input elasticity. Using this definition, dividing equation 2 by t, and writing the proportionate shift in the production function with respect to technology as $\hat{A}$, equation 2 can be written as:

$$T\hat{F}P = \hat{A} + (\epsilon - 1) * \hat{X} \qquad (3)$$

$\hat{A}$ captures the shift in the production function due to technical change and is often considered the only effect technology has on productivity, and $\hat{X}$ is the rate of change in the aggregate input index with respect to a change in the technology variable.

The first term in equation 3 measures the direct effect that technology has on productivity. The second effect is a scale effect, which equals zero if the production function is constant returns to scale.[18] All the parameters required for calculating $\hat{A}$ and ϵ can be estimated from a production function. In practice, there are seldom enough degrees of freedom to estimate a production function without avoiding restrictive prior specifications.

Capalbo (9) derived an alternative approach to identify and divide the sources of productivity growth from relationships established by Denny and others (15), and Ohta (33). Capalbo's approach for breaking TFP growth into several components follows. Write a cost function as:

$$C = G(t, W, Y) \qquad (4)$$

and a cost line as

$$C = \Sigma X_i W_i \qquad (5)$$

[18] Often, time represents technology so equation 3 is equivalent to the effect of time on total factor productivity. If equation 1 were differentiated with respect to time, equation 3 would contain six terms: the same terms as above multiplied by the rate of technical change with respect to time, plus three similar terms that represent the derivatives directly with respect to time. Empirical evaluation of such an expression is beyond the scope of this report.

where t represents technology, W_i is the ith input price, Y is output, and X_i are individual inputs. Differentiate the log of a cost function with respect to the technology to get:

$$\frac{\delta LnC}{\delta Lnt}=\frac{\delta LnG}{\delta Lnt}+\sum\frac{\delta LnG}{\delta LnW}*\frac{\delta LnW}{\delta Lnt}+\frac{\delta LnG}{\delta LnY}*\frac{\delta LnY}{\delta Lnt} \tag{6}$$

Using Shepard's lemma, and dividing by t, equation 6 can be rewritten as:

$$\hat{G}_t=\hat{C}_t-\sum_i^I *s_i*W_i-\epsilon_{cy}*\hat{Y} \tag{7}$$

where s_i is the share of expenditures on the ith input, $\hat{C}_t$ is the proportionate change in the cost function with respect to technical change and includes direct and indirect effects, $\hat{G}_t$ is the direct proportionate shift in the cost function with respect to technical change, W_i is the proportionate change on input prices with respect to technology $(\delta(W)/\delta t)*(1/W)$, ϵ_{cy} is the elasticity of cost and equals the inverse of the elasticity of scale, and $\hat{Y}$ is the proportionate rate of change of output with respect to technology $(\delta(Y)/\delta t)*(1/Y)$.

Differentiate the cost line with respect to technology to get:

$$\frac{\delta C}{\delta t}=\sum_i^I X_i*\frac{\delta W_i}{\delta t}+\sum_i^I W*\frac{\delta X}{\delta t} \tag{8}$$

Multiplying the right side of equation 8 by (W_iX_i/W_iX_i), dividing by C, and rearranging:

$$\hat{C}-\sum_i^I\frac{(W_i*X_i)}{C}*\hat{W}_i=\sum_i^I\frac{(W_i*X_i)}{C}*\hat{X}_i=\hat{X} \tag{9}$$

where $\hat{X}$ is the proportionate change of a Tornqvist (aggregate) input index with respect to technology.

Using equation 9, equation 7 can be written as:

$$\hat{G}_t=\hat{X}-\epsilon_{cy}\hat{Y} \tag{10}$$

Now differentiate the production function representing the numerator in equation 1 (with respect to technology) and use the fact that the elasticity of the cost function is the inverse of the elasticity of scale:

$$\hat{Y}=\hat{A}+\frac{1}{\epsilon_{cy}}\hat{X} \tag{11}$$

Substitute equation 11 into equation 10 to get:

$$-\hat{G}_t=\epsilon_{cy}\hat{A} \tag{12}$$

Take equation 3 and use equation 12 and the inverse relationship between the elasticity of scale and the elasticity of the cost function to get:

$$T\hat{F}P=\frac{-\hat{G}_t}{\epsilon_{cy}}+(\frac{1}{\epsilon_{cy}}-1)*(\hat{X}) \tag{13}$$

Solve equation 11 for $\hat{X}$ and substitute this into equation 13:

$$T\hat{F}P=\frac{-G_t}{\epsilon_{cy}}+(\frac{1}{\epsilon_{cy}}-1)*(\epsilon_{cy}\hat{Y}+\hat{G}_t) \tag{14}$$

Equation 14 reduces to Capalbo's formula for dividing productivity growth:

$$T\hat{F}P=-\hat{G}_t+(1-\epsilon_{cy})*\hat{Y}+\mu \tag{15}$$

The error term in equation 5 of the text is added to account for missing variables such as an efficiency effect. This derivation of equation 15 in essence follows the procedure introduced and described by Capalbo (9). However, several minor differences between Capalbo's report and this report must be addressed. First, Capalbo represented technology by time so all proportionate shifts are with respect to time. This report used an index of Brazil's tractor/mule ratio to represent technology. Unfortunately, there was little advantage to using this technology index since the tractor/mule index tracked time closely.

Equations 5 (text) and 15 (appendix) need to be amended slightly since the right side of equation 9 does not truly equal the proportionate change in the Tornqvist (aggregate) input index. The reason for this (2, 11) is that when the production technology is not restricted to be constant returns to scale, the correct weights on each input are the ratio of expenditures on each input to revenues, rather than cost shares. In reality, the right side of equation 9 ($\hat{X}$) must be multiplied by the ratio of revenues to costs.

This point complicates the algebra of the above derivation. Equations 10, 12, and 13 are more complex. Fortunately, after much algebra, many of the additional terms fall out and the final equation is only slightly altered. The division of total factor productivity growth becomes:

$$T\hat{F}P=-\hat{G}_t*(C/R)+(1-(C/R)*\epsilon_{cy})*\hat{Y}+\mu \tag{16}$$

where (C/R) represents the ratio of cost to revenues. The amended equation is a more general version of Capalbo's equation. When there are constant returns to scale, the C/R ratio equals 1. This report used the amended equation to derive the results reported in table 4.

Appendix table 1--Output, input, and productivity indices for Brazil crop production

Year	Outputs	Inputs	Productivity
1968	1.00	1.00	1.00
1969	1.03	.99	1.04
1970	1.09	1.01	1.08
1971	1.14	1.06	1.07
1972	1.17	1.17	1.00
1973	1.20	1.21	1.00
1974	1.30	1.37	.99
1975	1.36	1.41	.96
1976	1.38	1.38	1.00
1977	1.50	1.36	1.11
1978	1.38	1.44	.95
1979	1.48	1.35	1.08
1980	1.63	1.48	1.10
1981	1.62	1.43	1.13
1982	1.75	1.45	1.18
1983	1.79	1.42	1.26
1984	1.92	1.59	1.21
1985	2.16	1.67	1.29
1986	1.95	1.66	1.17
1987	2.19	1.72	1.26

[1] See (2) for derivation of these indices.

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