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Explaining Agricultural Growth in Viet Nam

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1. Introduction

Vietnam has attained superb performance of rapid growth in agriculture following the series of agrarian and institutional reforms adopted since the early 1980s shifting from a centrally planned to a market economy. By 1989 after being a net importer of rice for nearly three decades Vietnam has emerged as one of the top rice exporter. Indeed, the country experienced the world highest growth of agricultural production and exports in the past decade. Throughout the 1990s agricultural output has grown at 5.9 percent per annum. Even though the role of agriculture in the economy has declined, its importance is still considerable, as it provides about 60% of labor force, about 24% of total GDP and 34% of total exports (in 1999).
It is important, however, to examine the growth pattern of the agricultural sector over the past decades in order to identify the crucial growth-explaining factors, as well as to understand whether or not these factors will be adequate in the future. Growth of agriculture in Vietnam over the past two decades was the result of a combination of institutional factors such as new incentives to farmers recognized by Doi Moi as autonomous economic agents and physical factors such as land, labor, capital (in the form of machines, working animals, irrigation system and so on), and intermediate inputs such as fertilizer.

In this paper, we argue that the role of science and technology in explaining growth over the past decade is relatively small. Most of the growth could be attributed to the increase in use of production factors, rather than to the growth of total factor productivity. The growth of total factor productivity can be thought as the result of new knowledge and technological change induced by the application of science and technology. If the total factor productivity growth had been small, it would follow that the contribution of science and technology to agricultural growth is relatively small.

Most of the studies on agricultural growth in Viet Nam using data for the 1980s and early 1990s showed the overwhelming impact of radical institutional changes in Vietnam's agricultural sector within that period.

[1] This paper is a background technical paper for the Asian Development Bank funded *TA 3223 on Agricultural Sector Program*. The TA was implemented by ANZDEC, Ltd and the Executing Agency was the Ministry of Agriculture and Rural Development, Government of Viet Nam. The views expressed in the papers do not necessarily reflect the views of Asian Development Bank nor the Government of Viet Nam. The opinions and conclusions reached in this paper are only the responsibility of the authors.

Using Divisia input and output indices estimated from a cross-section of countries in the region Cristina C. David (1994) found that growth in TFP contributed around 30 percent of growth in Vietnam's crops output in the 1980's[2].

Based on the growth accounting analysis by Vali Jamal and Karel Jansen (http://www.ilo.org/public/english/dialogue/sector/papers/agrtrans/128e3.htm) which also used Divisia indices derived from cross-countries studies, TFP growth was found to contribute 57 and 0.4 percent of the growth in aggregate agricultural output (excluding non-crops activities) over the periods 1984-88 and 1988-95, respectively. These results are comparable with our 1985-89 estimates. Because the study used aggregated agricultural data and covered only a few post-reform years, it is difficult to accurately gauge the potential of Vietnam's future growth based on Jamal and Jansen's analysis. However, their analysis provides some clue of the sharp reduction of agricultural TFP in the early 1990's when the policy-induced momentum of the growth was about to be exhausted.

In this study, we apply a growth accounting method to national/regional data for aggregate agricultural gross output. Further insights into the sources of Vietnam's agricultural growth in this period can be obtained from a production function. A log-linear Cobb-Douglas function has been used here, in which output is attributed to land, labor, fertilizer and machines. Data were compiled from 61 provinces over 15 years and aggregated to a national/regional level to indicate Vietnam's potential growth in agricultural production.

Our analysis is divided into two periods that correspond to major shifts in Vietnam's agricultural policy. The first period (1985-89) covers the transformation of the old collective system to the family-based farming. In the second period (1990-99), the country shifts to the post-reform period.

Using estimated production function, TFP index could be obtained by subtracting land, labor or other physical inputs from a total agricultural output index. As a residual term, TFP captures all nonphysical input factors that affect output growth over time. Technological change, weather, institutional/policy change, and other external shocks can all affect production efficiency (e.g., change in the output level given input levels).

Technological change is usually a sustainable source of TFP growth (i.e., it is a long-term effect). Changes in institutions or policy could also provide a long-term impact.

[2] Interestingly, this result may inadvertently have been the source of a widely cited result about the contribution of science and technology to agricultural growth in Viet Nam. In the foreword to the Directory of Agricultural Research Organizations published in 2000, the 30% contribution of science and technology was cited, but no specific study was mentioned.

But most other sources of TFP growth provide only short-term effect on productivity. The growth accounting method by itself cannot identify short- versus long-term sources of TFP growth. The influence of short-term effects on TFP growth can be moderately reduced by studying a longer period of time. Since the weather strongly effects agricultural production, the extreme cases in some particular years could be eliminated using the procedure of three-year moving average.

The growth rate and the contribution of the agricultural TFP seem to be quite different in these two periods, implying strong institutional and policy impacts within the reform period and exhausted influence of institutional and policy changes since the post-reform period. The reason that most of the changes in TFP are attributed to institutional and policy changes rather than agricultural research and extension is that over these two periods there is no discernible structural change in research and extension system in Viet Nam. Expenditures on research were extremely low (both in absolute terms and relatively to agricultural GDP) in both periods. For extension, even though the extension system was formally created in 1994 and become operational in 1996, the funding and the organization of extension activities did not change radically over the two periods. Without going into details, it could certainly be said that during the late 1980s the research and extension system was not much more prominent than during the 1990s.

The study is organized into 6 Sections including this introduction. Section 2 provides and overview of growth performance of Viet Nam over the period 1985 to 1999. Section 3 examines partial factor productivity growth. Section 4 presents the analysis of total factor productivity. Section 5 derives some implications for future agricultural growth strategy in Viet Nam. Section 6 gives the conclusions.

2. Growth and Performance in Vietnam's Agricultural Sector

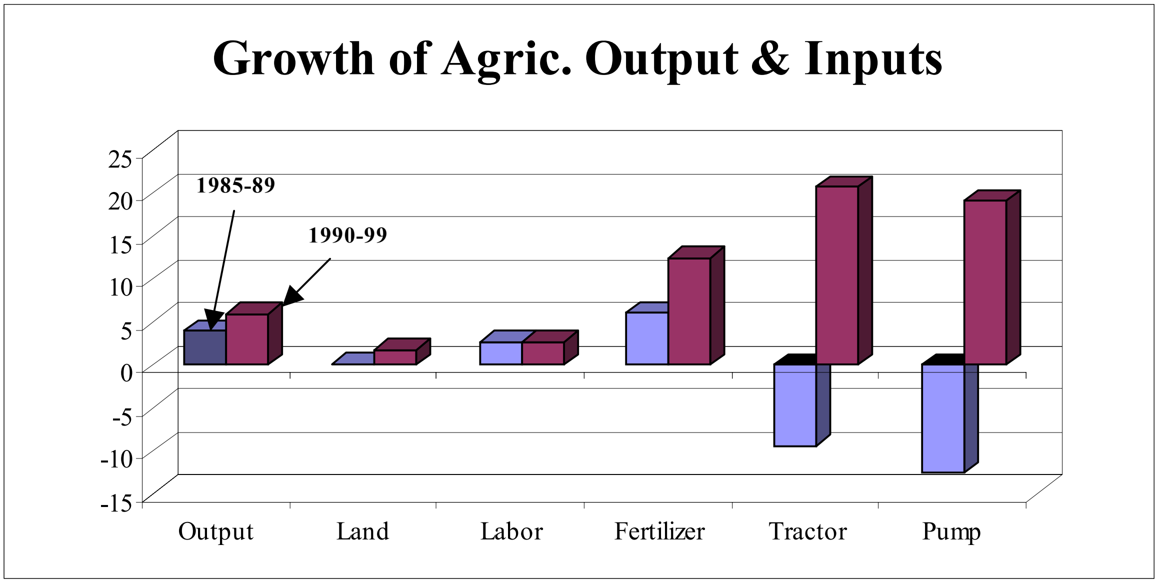
This section provides an overview of the trend in output and input for Vietnam's agriculture. The analysis covered the period from 1985 to 1999. The description of trends in growth of agricultural gross output covers both the crop and livestock sectors. Due to lack of input data on livestock, analysis of trends in input use pertain only to the crop sub-sector.

All agricultural data used for the analysis have been compiled by the General Statistics Office. However, many data are not available or may be inaccurate, caution must be taken in interpreting the results. Despite data limitations, however, the analysis was attempted to infer broad trends and patterns of agricultural production changes over the concerned period.

Table1: Annual percentage growth of Agricultural Inputs and Output in Vietnam 1985-99

Period	Output	Land	Labor	Fertilizer	Tractor	Pump	Work Animal
1985-89	3.91	0.09	2.64	6.04	-9.41	-12.56	4.77
1990-99	5.91	1.75	2.68	12.39	20.71	18.99	0.94
1985-99	5.11	1.22	2.74	11.14	13.25	11.21	1.87

Source: computed based on GSO data
Note: The growth here is a compound rate derived from three-year moving average data



During the late 1970s attempts to strengthen the collectives resulted in high investment on irrigation and machinery without consideration of the inefficiency of the system. However, with the introduction of reforms in 1981 efficiency of agricultural production was improved and the structure of input use was changed. Investment in irrigation and machines declined, while fertilizer input increased, reflecting the more intensive cultivation of land. Macroeconomic instability of the mid-1980s with hyperinflation rate of more than 300 percent resulted in a sharp decline in purchased inputs (fertilizer and machines), but efficiency continued to improve. The more radical reforms of 1988-89 led to equally more radical changes in agricultural production. In the following years, agricultural growth was mainly determined by the increase in purchased inputs. Table 1 suggests that the shift of responsibility to households in the late 1980s resulted in a sharp jump in the efficiency of production, but this jump was simply a one-off catching up; once efficient production was established, further output growth required increased inputs.
During the 1990s the output and all the physical inputs boosted drastically, making of Viet Nam the fastest growing agricultural sector in the world over the past decade. However, there is some evidence of over-usage of inputs. The increased use of

purchased inputs was made possible by a sharp rise in the availability of rural credit as a result of reform in banking system.

Table 2: Growth of Agricultural Inputs and Output by Regions in Vietnam, %

	Output	Land	Labor	Tractor	Pump	Fertilizer	Animal
1985-89							
North	2.59	-0.04	3.35	-1.01	-11.62	-3.98	5.05
Central	1.00	-0.91	2.54	-7.74	-11.56	7.67	4.83
South	5.98	0.48	2.09	-11.61	-12.77	13.54	4.22
1990-99							
North	5.19	-1.10	3.09	19.34	23.43	14.41	1.70
Central	3.65	0.06	3.38	18.59	18.34	5.78	1.61
South	6.98	3.45	1.89	21.37	18.59	12.14	-1.91
1985-99							
North	4.12	-0.67	3.45	14.08	10.94	11.37	2.68
Central	2.53	-0.29	3.30	12.72	9.36	5.29	2.66
South	6.59	2.48	1.80	13.14	11.39	12.31	-1.02

It is worthwhile to note that growth pattern of agricultural output and inputs across regions throughout the country shows marked differences. Table 2 shows that both the North and the South during the last decade experienced higher rate of growth with respect to gross output and purchased fertilizer as compared to that in the central. In all regions agricultural labor increased relatively fast, but the pace of labor increase appeared to be much higher in the North and the Central in comparison to that in the South. It is interesting, however, that cultivated area is declining in absolute and relative terms in the North and the Central, but it grows relatively fast in the South during the last 15 year. The land-labor ratio, thus, is found to be much favorable in the south than in the rest of the country supporting the development of agricultural production for southern farmers. It is strange at the first glance that during the 1990's machineries steadily increased at a rather high rate not only in the South, where more land availability for the farmers was observed, but also in the other two regions with the opposite land condition. One of reasons for that is perhaps instead of keeping animals for draft power farmers likely want to invest in machines, which are now become more affordable and plentiful in varieties and sizes. Indeed, there is an obvious tendency of reducing growth rate of working animals in the North and the Central. Due to lack of data it is hard to identify the quality differences with regards to the used machines between regions, although it is thought they are not the same, i.e. southern farmers might have bigger machines in terms of size and horse power.

3. Partial Factor Productivity

A clear understanding of the productivity measurement issues is central to any attempt to interpret the economic effects of investments in agricultural R&D. Productivity index in a conventional notion is simply a measure of the quantity of outputs divided by a measure of the quantity of inputs.
The most widely used indicators of productivity are Partial Factor Productivity (PFP) which express a single output per unit of a particular input, such as land or labor. These partial factor productivity (PFP) indexes divide a quantity index of aggregate output (Q) by an index of the quantity of a particular input, or input aggregate, X_i: that is, $PFP_i = \frac{Q}{X_i}$.
Changes in PFP may arise from changes in the relationship between measured inputs and outputs - or from changes in the use of other (unmeasured) inputs. Thus an increase in yields (land productivity) could simply reflect an increased use of fertilizer, while an increase in labor productivity may be attributable to increased use of machinery and other capital items. Partial factor productivity indexes cannot, by themselves, distinguish between the effects of changes in the state of technology and changes in input mix induced by shifts in relative prices, and so alternative productivity measures are commonly constructed.
We now turn to an examination of trends in productivity measures for Vietnam's agriculture.

Table 3: Land, labor and Fertilizer Productivity

	Land PFP		Labor PFP		Fertilizer PFP		Land/Labor	
	1985-89	1990-99	1985-89	1990-99	1985-89	1990-99	1985-89	1990-99
Level of PFP (Unit: M. Dong/Ha; M. Dong/Labor; M. Dong/Ton; Ha/Labor)								
North	8.802	12.568	2.975	2.974	93.573	55.211	0.339	0.242
Central	9.326	11.240	3.166	2.791	135.903	133.112	0.340	0.251
South	7.121	9.732	3.757	5.294	107.630	79.713	0.528	0.542
Country	7.980	10.666	3.350	3.844	105.395	73.694	0.420	0.362
Annual Smoothed Compound Growth (%)								
North	2.65	6.36	-0.71	2.03	6.90	-8.28	-3.25	-4.09
Central	1.93	3.59	-1.54	0.22	-6.36	-2.55	-3.40	-3.26
South	5.47	3.42	3.80	4.99	-7.18	-5.22	-1.61	1.53
Country	3.81	4.09	1.22	3.15	-2.40	-6.15	-2.50	-0.91

Source: Computed based on GSO and MARD data
Note: The agricultural gross output used to compute related partial factor productivities is measured at constant prices of 1994.

Table 3 presents partial productivity measures for land, labor and fertilizer in Vietnam for the period of 1985-1989 to 1990-1999. It also includes a smoothed

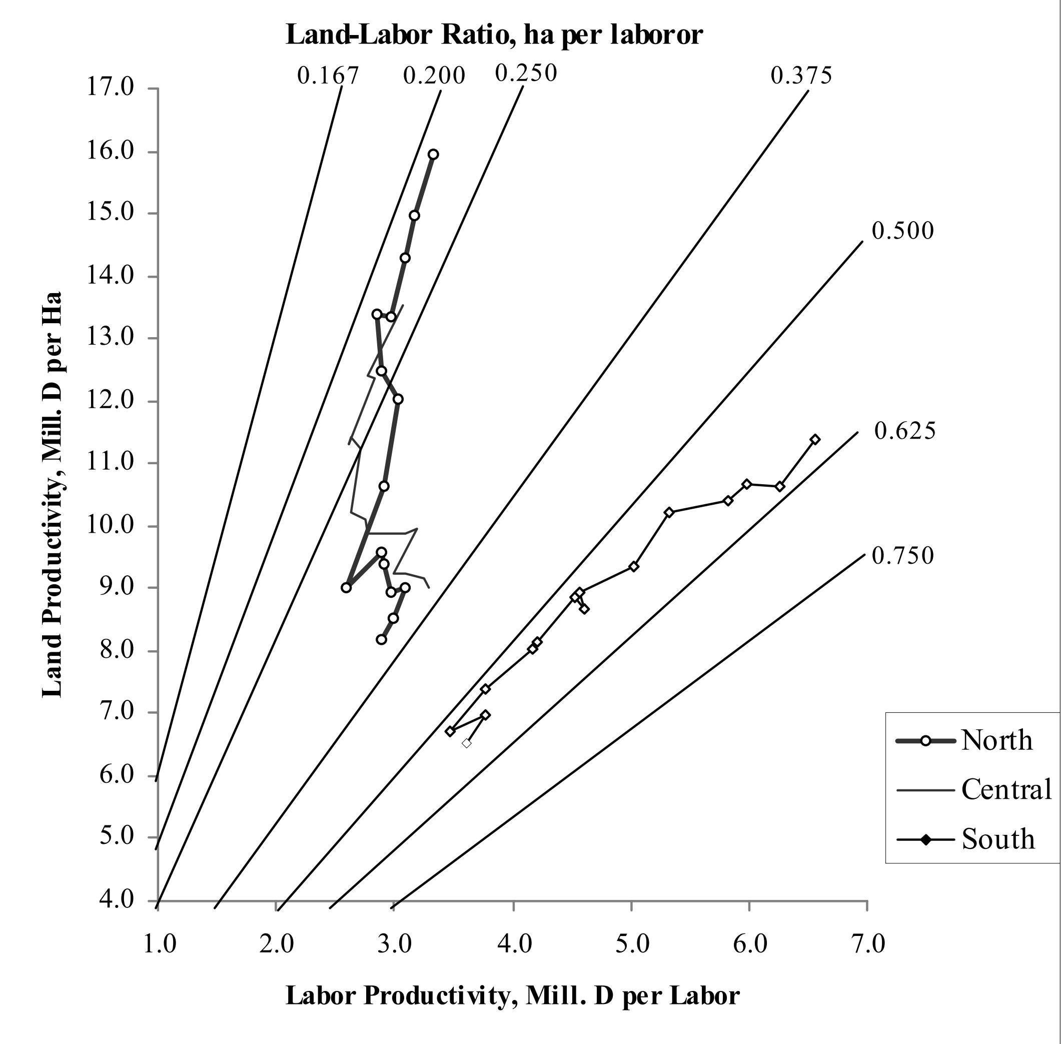
compound annual growth rate for each of the factor productivity measures. As would be expected, given their endowments of land and labor, labor productivity is relatively high for the South, and relatively low for the Central and the North. For the country as a whole, labor productivity grew at an average annual rate of 3.15 percent during the last decade, which is much faster as compared with that of 1.22 percent in period of 1985-89. However, table 3 also shows that there has been significant variation around that average among regions. Land productivity has been highest in the North, followed by the Center, and lowest in the South. Land productivity has grown rapidly in all regions over years, but the position in terms of land productivity growth between regions has experienced a reverse change in period of 1985-1989 to 1990-1999. While the South experienced the highest growth of land productivity during 1985-89, the South had the lowest growth in land productivity during the last 10 years (1990-99). Conversely, from a much lower position, the North has achieved the country highest growth of land productivity in 1990-1999.
It is of interest also to note that while both land and labor productivity tend to increase over the last decade, the productivity of purchased fertilizer decreased substantially in all regions throughout the country implying a decreasing return to scale of this intermediate input during 1985-1999.

The changes in partial factor productivities reflect the joint influence of technological change and changes in factor mix. Table 3 shows the annual average of land-labor ratios (hectares per unit of labor) for the three regions in Vietnam, between 1985-1989 and 1990-1999.
Land-labor ratios, calculated as an annual averages from 1990-1999, vary among regions from a high of 0.542 in the South to a low of 0.242 in the North, with a country average of 0.362. In the North and the Central the average level of land-labor ratio has markedly reduced from the period of 1985-1989 to 1990-1999, while for the South it has been grown. Table 3 also shows annual average growth rates in the land-labor ratios in 1980's and 1990's for three regions, and the whole country. The national average rate was -2.50 percent in 1985-1989 and -0.91 in 1990-1999. The rate varies much among regions and between periods. Within 1985-1989 land-labor ratio declined in all of three regions by around 1.6 - 3.4 % annually. This ratio decreases at much quicker rates in the North and the Central regions (-4.1 and -3.3 %, respectively) in the last decade, but in the South for the same period a positive rate of 1.5% for the land-labor ratio has been observed

These adjustments in factor proportions and factor productivities may be induced by several types of technical changes, including changes in techniques, genetic improvements, changes embodied in mechanical inputs, changes in irrigated land, and changes in the stock of knowledge.

Figure 1 combines the information on marginal productivities of land and labor, and the information on land-labor ratios (from table 3). In figure 1, the horizontal axis measures labor productivity, the vertical axis measures land productivity, and the sloping lines represent constant land-labor ratios. The South is represented in the lower right-hand corner. The graph shows that between 1985 (the lower endpoint) and 1999 (the upper endpoint), both land and labor productivity rose, but the structure of their growth are markedly different between regions. In the North and the Central during the whole 15-year period land productivity improved faster than labor productivity, while in the South both two measures developed nearly at the same pace. The land-labor ratio slightly increased in the South, and decreased in the North and the Central.

Figure 2: Land & Labor PFP in Vietnam, 1985-99



4. Total Factor Productivity

A more meaningful measure of changes in productivity attributable to R&D-induced changes in technology is given when ideal index number procedures are used so that all inputs are properly accounted for.
A *total* factor productivity (TFP) index includes an index of all inputs used (*X*) in production: $TFP = \frac{Q}{X}$. This type of index is comprehensive in that all the relevant outputs are included in the output quantity index, Q, and all the relevant inputs are included in the input quantity, X. In practice, the available data make it impossible to get a truly comprehensive accounting of all the inputs used in production, so a TFP index is really a conceptual construct rather than a practical reality. Instead, what are usually reported are only an approximation of the TFP index. There are usually some inputs are omitted in the TFP approximation procedure, but this only changes the degree of the problem of interpreting productivity measures (Alston and Pardey, 1996).

As mentioned somewhere above, for our analysis TFP (defined as a ratio of total output to total input) is estimated using a log-linear Cobb-Douglas production function. The conceptual approach of how to measure TFP as well as its contribution to the output growth is presented bellow.

As gross output (Q) can be a function of all factor inputs that is $Q = F(X_1, X_2, ..., X_n; S\&T; I\&I)$. Where Q is output; X are measured physical factor inputs; S&T: Science and Technology; I&I: Infrastructure and Institutions.

Since, total factor productivity, TFP, is understood as a combination of S&T and I&I. Thus the gross output function can be reformulated as follows:

$$Q = F(X_1, X_2, ..., X_n; TFP)$$

If this production function is specified as:

$$\log(Q) = \alpha_0 + \alpha_1 \log(X_1) + \alpha_2 \log(X_2) + ... + \alpha_n \log(X_n) + \log(TFP)$$

$$Q = A_0 \cdot \exp(\sum \alpha_i \cdot \log(X_i)) \cdot TFP,\ i=1,...,n$$

$$Q = X \cdot TFP \text{ or } TFP = \frac{Q}{X}$$

Where X can be defined as an index of inputs

$$X = \exp(\sum_{i=1}^{i=n} \alpha_i \log(X_i))$$

$$\Delta Q = \Delta X + \Delta TFP$$

Where $A_0 = \exp(\alpha_0)$; Δ *is proportional rate of change.*

Therefore, the contribution of TFP to the growth of gross output could be derived as follows:

$$\delta = \frac{\Delta TFP}{\Delta Q} \bullet 100$$

In order to calculate the total factor productivity for Vietnam's agriculture we decide to use regression analysis and specify agricultural production in the form of log-linear function. This production function with its estimated coefficients using GSO's time-series data for 61 provinces in Vietnam in the period of 1985-1999 is presented as follows (For more details, see the appendix):

Log(Agri_GO) = 2.5702 + 0.3748Log(AgriLand) + 0.3100Log(AgriLabor) + +0.24119Log(Fertilizer) + 0.03987Log(Tractor) + 0.01515 Log(Pump)

Where:

Log(Agri_GO): Logarith of Agricultural Gross Output by provinces at 1994 prices (in billion Dongs);

Log(AgriLabor): Logarith of Agricultural Labor by provinces (in 1000 person);

Log(AgriLand): Logarith of Agricultural Land by provinces (in 1000 ha);

Log(Fertilizer): Logarith of total fertilizer consumption by provinces (in 1000 tons);

Log(Tractor): Logarith of Tractor used for agricultural production by provinces (in pieces);

Log(Pump): Logarith of Pump used for agricultural production by provinces (in pieces).

The derived TFP index and its contrubution to the growth of agricultural output in Vietnam in the concerned period can be seen in table 4.

Table 4: TFP & its Contribution to agricultural production growth in Vietnam

Years	North	Central	South	Country
Annual average percent				
Output growth rate:				
1985-89	2.59	1.00	5.98	3.91
1990-99	5.19	3.65	6.98	5.91
TFP growth rate:				
1985-89	2.74	-0.81	2.54	2.16
1990-99	0.04	0.17	1.04	0.32
TFP contribution:				
1985-89	105.87	-81.77	42.54	55.33
1990-99	0.74	4.57	14.85	5.42

Over the period 1985 to 1989, total factor productivity in Vietnam's agriculture increased at an average annual rate of 2.16 percent. However, as expected, table 4 shows that there is a substantial fall in the rate of TFP growth in the last decade as compared to that of the late 1980's (i.e. from 2.16 percent it fell to just only 0.32 percent). The high growth rate in 1985-89 captures the efficiency gains from institutional changes. This period saw a shift from the collective production system to the household-based production; less administrative intervention in agricultural production; and the boost of free-market activities. Table 4 suggests that the strong impact of radical policy changes on production efficiency under Doi Moi was simply a one-off catching up. Once efficient production was established, further output growth required increased inputs. It is important to note that the efficiency gained from chages in total factor is markedly different among the regions. In the Central region TFP growth rate had a negative value, since the output almost did not change, while the labor and purchased inputs increased relatively fast. The North and the South where conditions are more favorable for agricultural production, the pattern of growth is nearly the same starting with high rate in the reform period and slowing down sharply during the last decade.

Table 5: Decomposition of growth of agricultural Gross Output in Vietnam

Factor	Contribution to Output Growth,	
	1985-89	1990-99
Labor	20.9	14.1
Land	0.9	11.1
Tractor	-9.6	14.0
Pump	-4.9	4.9
Fertilizer	37.3	50.6
TFP	**55.3**	**5.4**
Agric. Gross Ouput	100.0	100.0

Source: Calculated using output factor elasticities derived from regression analysis and the rate of change in inputs used.

Table 5 indicates the importance of TFP in the late 1980's accounting for around 55 percent of the growth in agricultural production. The efficiency gains from institutional reforms can occur at any given level of technology. Therefore, the impact on growth lasts only for a limited time. A slow-down in TFP growth in the post-reform period (1990-99) indicates that when Vietnam's agricultural production moved to its production possibility frontier at the given level of technology, efficiency gains from further reform became smaller. Hence, additional growth in TFP would have to come from technological change.

5. Past Strategy and Future Challenges

Past strategy no more adequate

Past performance of Viet Nam agriculture can be summarized into three statements. First, the sector has become increasingly market-oriented over the past decade. This has been the result of doi moi policies and particularly of liberalization of trade and marketing and allocation of land use rights to farmers. Second, the incentives released by the new policy and the accompanying investment have produced an impressive growth of agriculture, making of Viet Nam the fastest growing agricultural sector in the world over the past decade. The success in a number of subsectors such as rice, coffee, and fishery is well documented and will not be repeated here. Third, growth in income of the average population has been characterized also by improvement in the conditions of the poor and resulted in a dramatic reduction of poverty.

Growth of agriculture in Viet Nam over the past decade was the result of a combination of institutional factors such as new incentives to farmers recognized by Doi Moi as autonomous economic agents and physical factors such as land, labor, capital (mostly in the form of irrigation system), and intermediate inputs such as fertilizer. The role of science and technology in explaining growth over the past decade has been relatively small. According to the analysis resulting the previous section, most of the growth in the last ten years could be explained by increasing factors of production, rather than by total factor productivity growth. Total factor productivity growth can be thought as the result of the application of new knowledge and technical change induced by the application of science and technology. Since this total factor productivity growth has been small, it follows that the contribution of science and technology to agricultural growth in Viet Nam, was relatively small[3] during the 1990s. Total factor productivity growth could not explain more than 5 percent of growth in agricultural output during the period 1990 to 1999. Therefore, in spite of a remarkable growth during the 1990s, agricultural growth in Viet Nam has been the result of increasing the use of inputs such as labor, land, fertilizers, tractors, and pumps, rather than increasing total factor productivity.

It is unlikely that this strategy will be able to sustain similar growth in the future. There are three main reasons for this. First, the growth of labor force in agriculture is already starting to decline and with very little land available per farmer, the attractiveness of farming is going to decline further. Second, new investment in irrigation exhibits decreasing marginal returns as the stock of irrigation capital is already very high and requires increased repair and maintenance rather than new expansion. Third, a large part of the growth of agriculture in Viet Nam over the past decade was due to rice production growth and the growing demand for rice exports resulting from a more liberalized trade system of Viet Nam. However, Viet Nam has already captured a large share of world rice markets so that both domestic and international demand for rice will start to grow at a much lower rate than in the past. Future growth rates of rice production of 5 percent per year will not and should not be a reason for self-congratulatory statements, unless that increase meets a growing demand. The events of the most recent past and the future scenario for world rice demand suggest that demand for Vietnamese rice is not likely to increase at more than 3 percent per year.

Future growth of agriculture in Viet Nam will have to come not just by adding more labor and capital/intermediate inputs. It will have to come from an increasing demand (both in Viet Nam and internationally) for high-value agricultural products. That will imply a more diversified agricultural system, where a variety of high-quality products are produced for the market. This will also imply a change from a perspective that is focused on commodities (for example tons of paddy, tons of coffee, tons of cashew, etc.) to a perspective that is focused on products (for example packaged jasmine rice long grain and 100% unbroken, specialty arabica coffee toasted and packaged for

[3] This small contribution of science and technology to total factor productivity growth should not be necessarily interpreted as a criticism of the research and extension system in Viet Nam. As it will be argued later, the research and extension system in Viet Nam had done an important contribution to agriculture. However, because of the limited resources devoted to these institutions, their aggregate contribution could not be as big as the one represented by physical factors.

European markets, vacuum fried jackfruit chips packaged for the Japanese supermarkets, pesticide residue free fresh vegetables for the Australian market, etc.). This shift of perspective is basically a shift from low-valued bulky commodities to high-valued, high-quality processed products. More generally, it is a shift from a focus on increasing production volumes to increasing production values.

In contrast to the past decade of growth in Viet Nam, the next two decades will require more than just labor, fertilizer, and irrigation. They will require a policy environment, promoting competition and utilizing science and technology applied to agricultural production for meeting the demand of a more sophisticated market.

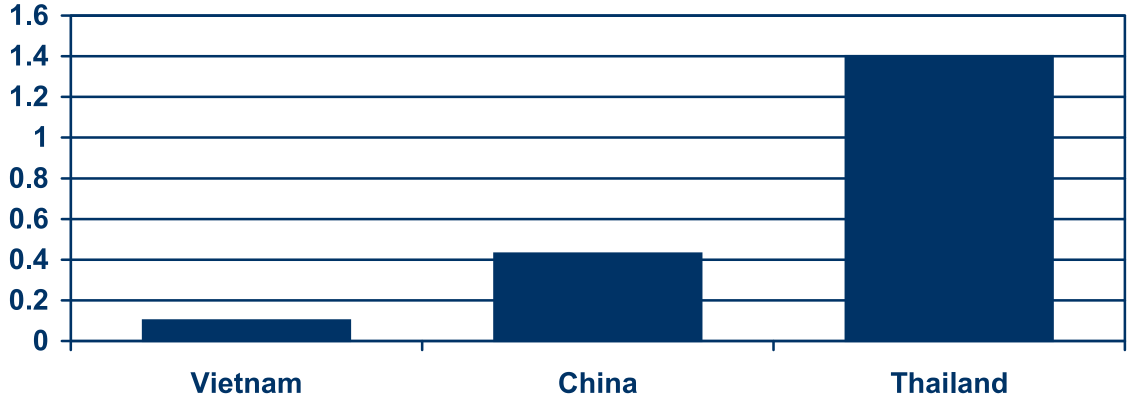
Competition will be necessary to lower cost of production and thus capture higher market shares and profits in international markets. Science and technology will be necessary to identify new production processes and innovative products that can increase productivity of the agricultural system to a much larger extent than addition of factors such as labor, irrigated land, and fertilizer. Agroindustry development and supporting market infrastructure and institutions will be necessary to capture higher value-added from agricultural production. Science and technology, competition and market supporting infrastructure and institutions, and agroindustry development are the key words of the new strategy for agricultural development.

The case for investment in research and extension

The case for investment in research and extension in Viet Nam is based on several arguments. First, numerous studies conducted in a number of countries worldwide have shown that investments in research and extension have high returns (of the order of 25-40% IRR) for the societies where they have been undertaken. Since these returns benefit society at large and not specific interest groups, there is a tendency for a market economy to under-invest in this type of activities, and therefore there is a role for state investment.

Second, the contribution of research and extension in Viet Nam has already being considerable relatively to the extremely low volume of investment in these areas. New rice varieties, hybrid maize, true potato seeds, new strains of cassava are just a few examples of the remarkable results that even little investment in research and extension could produce in Viet Nam. However, the investment has been too little to make any major contribution at the aggregate level.

Figure 3: Research Budget as Share of Agriculture GDP (%)



Third, a casual look at other successful agricultural systems in the region (for example China and Thailand) will convince that the commitment of Viet Nam to research and extension has been quite low not only in absolute value but also in relative value (for example Viet Nam spends only about 0.1 percent of agricultural GDP on agricultural research, whereas Thailand spend 1.4 %, that is almost 14 times as much in relative terms). If Viet Nam wants to compete with these successful neighbors, it would be better to follow their behavior in this respect. This is the case not just in theory, but also in the practical experience of farmers and consumers in Viet Nam. It is not unusual to see hybrid rice from China coming to Viet Nam and hybrid maize or new mango varieties coming from Thailand to Viet Nam).

Fourth, the requirements of high-value and high-quality agricultural products by domestic and international markets cannot be met without access to new technologies by farmers and enterprises. Sometimes, these new technologies are embodied in inputs or capital. Other times, they are embodied in management practices or production processes. In both cases farmers and enterprises need to have access to knowledge that they can use to improve their production and marketing process and therefore attain higher income. Currently, in Viet Nam very little of this knowledge is available to its farmers and enterprises. To a large extent, this is the result of little effort and resources committed to the generation and dissemination of technology and market information.

Fifth, the ideas expressed here, of the critical importance of science and technology to modernization and industrialization of Viet Nam agricultural system, are not new or inconsistent with the overall Government strategy expressed in a number of documents over time. However, these ideas are slow to be materialized in actual investments and budget allocation. Even though recent decisions by the government have increased the resources to agricultural research and extension, a lot more needs to be done both in terms of resources allocation and institutional changes. The proposed new Agricultural Sector Program would facilitate bridging the gap between declaration and implementation of priorities.

6. Concluding Remarks

This study is an attempt to explain the sources of agricultural growth by examining the overall trends and patterns of growth of agricultural production and productivity over the last 15 years in Vietnam. The growth of production, as well as labor, land, and total factor productivity during the reform period of 1980's has been found to be relatively high. The incentive structure induced by the new policy and the accompanying investment have brought about an astonishing performance of agriculture.

Most of this growth was from efficiency gains due to institutional reforms. After 1989, when efficiency gains had diminished, the growth rate of TFP fell. In the last ten years (1990-99), the increase in use of inputs, especially intermediates/capital, became major sources of growth in Vietnam's agricultural sector. Science and technology have relatively small role in agricultural growth and could not explain more than 6 percent of growth in agricultural output during the period 1990 to 1999.
The old development strategy relying on increasing the use of inputs such as labor, land, fertilizers, tractors, and pumps, rather than increasing total factor productivity is unlikely will be able to sustain similar growth in the future.

Sustainable TFP growth is a key factor in maintaining growth in Vietnam's agriculture. Although we argue that TFP growth fell after 1989 due to the exhausted effect of institutional changes, a quantitative analysis is needed to decompose the different sources of TFP growth. It is not possible without more and better quality data than what are now relatively available. The country must invest in developing the appropriate data for monitoring and analyzing productivity growth. As in Viet Nam agriculture continues to be the major source of employment, income, and foreign exchange. Increasing productivity growth is the only way to achieve long-run world competitiveness of the sector.

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Appendix 1:
Result of Agricultural Production Function, 1992-1999 by Provinces in Vietnam

1. Description of the data used in estimating the production function (and partial factor productivity):

In estimating the aggregate agricultural production function in Vietnam, the data on agricultural production output and related production factors for 61 provinces in period of 1985-1999 have been used. This dataset includes the following indicators: Agricultural Gross Output (in billion dongs), measured at fixed prices of 1994; Agricultural Land (in 1000 hectares); Agricultural Labor in 1000 persons; Fertilizer consumption in 1000 tons; number of tractors and pumps (in pieces). The data related to agricultural output, land, labor, tractors and pumps are mainly taken from GSO. However, some inconsistency has been found in GSO's new database issued in year 2000 with respect to agricultural labor of 1992-1999 compared with that of 1985-1991. According to some officers from GSO the disparity in data series on agricultural labor provided by GSO is due to the application of different terms for the same indicator of agricultural labor between these two periods. From 1991 backwards figures on agricultural labor means number of agricultural population at work age of 16-60 excluding unworkable people, while from 1992 upwards agricultural labor means total agricultural population at age of 16-60.
With respect to labor factor, because of the data problem as explained above, there are two options in using labor data for estimating agricultural production: 1) take shorter period of time for the analysis, i.e. from 1992 to1999 and use the data from the GSO's new database on total agricultural population at work age as a proxy for labor factor; 2) Alternatively, take a longer time period of 1985-1999 and use the workable agricultural population of work age as proxy for agricultural labor (it seems to be a much better proxy for labor factor as compared to total work-age population). For this purpose, data for agrilabor from 1985-1995 can be taken from GSO's old

dataset published in 1996, which is said to be in terms of workable population at work age, and the data for 1996-1999 could be taken from GSO's new database published in year of 2000, but with some correction to convert them from total agricultural population of work age to workable one based on the province-level annual average ratio of 1993-1995 between workable and total population of work age, which are given in GSO's new and old databases, relatively. Thus, only data for agricultural workable population of work-age from 1996 to 1999 need to be converted from the officially provided work-age population using the previous province-level three-year average conversion ratio (assuming this ratio is the same and does not change for 1996-99 period).
The advantage of the first option is that we might feel more "confident" in using data. However, its disadvantage is that we have shorter time period and therefore less data for our quantitative analysis. The second option has a very important advantage over the first one that is we could take use of more data availability for other related indicators, which do not encounter such a type of problem. Selecting the second option we could have, therefore, more opportunity to be able to improve the efficiency of running regression.

With respect to fertilizer input, since data on fertilizer consumption at provincial level is not available, the data series of nation-wide fertilizer consumption, compiled by Dr. Nguyen Van Bo (Director of MARD's Department for Science & Technology and Product quality) is used as a starting point for estimating province-level fertilizer consumption. The estimation of province-level fertilizer consumption is then based on the following assumption: the amount of fertilizer used is assumed to depend on crops yield and sown area, i.e. higher yield is related to higher level of fertilizer application and larger area requires larger amount of fertilizer applied.
The detailed procedure of estimating the total fertilizer consumption at provincial level can be described as follows:
Identify the quantitative relationship between per-ha use of fertilizer and crops yield by running regression of per-ha fertilizer consumption against crops yield using nation-wide data in period of 1975-1999. Assuming that this relationship holds true for all of 61 provinces, the level of per-hectare fertilizer applied for each of 61 provinces throughout the country can be computed. After all, the total fertilizer consumption in a particular province can be derived from multiplying the provincial per-hectare fertilizer use by total crops area [4].

2. Variables used in Production Function:

Log(Agri_GO): Logarith of Agricultural Gross Output by provinces at 1994 prices (in billion Dongs);

[4] The detailed calculations are available with the authors

Log(AgriLabor): Logarith of Agricultural Labor by provinces (in 1000 person) using agrilabor data of 1985-1995 from GSO's database published in 1996 (GSO's Old DBase); and adjusted labor data for 1996-1999 based on related data series provided in the GSO's New DBase;
Log(AgriLand): Logarith of Agricultural Land by provinces (in 1000 ha) using New GSO's DBase;
Log(Fertilizer): Logarith of total fertilizer consumption by provinces (in 1000 tons) derived from MARD's data on nationional consumption of fertilizer and GSO's data on agricultural gross output and sown areas by provinces;
Log(Tractor): Logarith of Tractor used for agricultural production by provinces (in pieces) using data from GSO's New DBase;
Log(Pump): Logarith of Pump used for agricultural production by provinces (in pieces) using data from GSO's New DBase;

3. Specification of production function and the Assessment of Factor Contributions to the GDP Growth:

Production function in general from:

$Q = F(X_i)$, where Q stands for production output and X_i stands for factors of production

General double-log form for production function:

$$LogQ = \alpha_0 + \alpha_1 LogX_1 + \alpha_2 LogX_2 + \alpha_3 LogX_3 + ... + \alpha_n LogX_n + \varepsilon$$

$$LogQ = \alpha_0 + \sum_i^n (\alpha_i LogX_i)$$

Where X_i denotes factors of production and ε is the residual of the regression

In our analysis the agricultural production function is specified as follows:

$$Log(Agri\_GO) = \alpha_0 + \alpha_1 Log(AgriLabor)_1 + \alpha_2 Log(AgriLand)_2 + \alpha_3 Log(Fertilizer)$$
$$+ \alpha_4 Log(Tractor) + \alpha_5 Log(Pump) + \varepsilon$$

Where: $\alpha_1, \alpha_2,, \alpha_3, \alpha_4, and \alpha_5$ are elasticities of the production output with respect to each of the concerned production factors.

Technological Change and its contribution to the growth:

The residual of the regression is that part of growth that could not be explained by other particular factors and therefore normally interpreted as induced by technological change. This concept is closely related to total factor productivity growth. Total differentiation of the production function gives a decomposition of the sources of production growth between technological change and increase in the use of individual factors:

$$\Delta Q = \Delta TFP + \sum_i \alpha_i \Delta X_i ,$$

Where Δ is rate of change and α_i is output elasticity of factor X_i, and ΔTFP is the rate of technological change. From this we obtain $\Delta TFP = \Delta Q - \sum_i \alpha_i \Delta X_i$.

The calculated Technological rate of change, then, divided by the rate of gross value of output gives a contribution of technological progress to the production growth:

$$\delta = \frac{\Delta TFP}{\Delta Q} \bullet 100$$

4. The Detailed Estimation Results of Selected Model for Agricultural Production Function in Vietnam using GSO's data of 61 provinces during 1985-1999

Ordinary Least Squares Estimation of Agricultural Production Function in Vietnam, based on GSO' data of 61 provinces during 1985-1999

Dependent variable is Log(Agri_GO)
892 observations used for estimation from 1 to 892
(Note: From total of 915 observations, i.e. 61 provinces for 15 years, only 892 valid cases with no missing values are included in the model)

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
Intercept	2.500300	0.05003800	49.9675 [0.000]
Log(AgriLand)	0.376910	0.01046600	36.0119 [0.000]
Log(AgriLabor)	0.320830	0.01248800	25.6916 [0.000]
Log(Fertilizer)	0.245020	0.00614220	39.8912 [0.000]
Log(Tractor)	0.040036	0.00476280	8.4061 [0.000]
Log(Pump)	0.013726	0.00353010	3.8881 [0.000]

R-Squared	0.96179	F-statistic F(5, 886)	4459.8 [0.000]
R-Bar-Squared	0.96157	S.E. of Regression	0.14421
Residual Sum of Squares	18.42450	Mean of Dependent Variable	6.8264
S.D. of Dependent Variable	0.73560	Maximum of Log-likelihood	464.6917
DW-statistic	**1.54170**		

The parameters of the production function estimated based on Ordinary Least Squares Method are statistically very significant. However, the model has suffered from autocorrelation problem (since Durbin-Watson statistic of 1.5417 is less than the tabular critical value) making the OLS estimators not best linear unbiased ones. To improve the efficiency of our estimation the problem should be corrected by using the Cochrane-Orcutt iterative procedure. The error-corrected estimation result is presented in the tables bellow.

Cochrane-Orcutt Method AR(12) Converged after 3 iterations

Dependent variable is Log(Agri_GO)
892 observations used for estimation from 1 to 892
(Note: From total of 915 observations, i.e. 61 provinces for 15 years, only 892 valid cases with no missing values are included in the model)

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
Intercept	2.570200	0.0473860	54.2397 [0.000]
Log(AgriLand)	0.374800	0.0113630	32.9855 [0.000]
Log(AgriLabor)	0.310000	0.0127620	24.2903 [0.000]
Log(Fertilizer)	0.241190	0.0056348	42.8036 [0.000]
Log(Tractor)	0.039869	0.0044440	8.9714 [0.000]
Log(Pump)	0.015148	0.0036753	4.1216 [0.000]

R-Squared	0.96873	F-statistic F(17, 862)	1570.8 [.000]
R-Bar-Squared	0.96811	S.E. of Regression	0.13099
Residual Sum of Squares	14.7911	Mean of Dependent Variable	6.8264
S.D. of Dependent Variable	0.73560	Maximum of Log-likelihood	549.1275
DW-statistic	**1.99460**		

The Estimated Agricultural Production Function in Vietnam, based on data of 61 provinces in period of 1985-1999 can be expressed in the following mathematical form:

Log(Agri_GO) = 2.5702 + 0.3748Log(AgriLand) + 0.3100Log(AgriLabor) +
+0.24119Log(Fertilizer) + 0.03987Log(Tractor) + 0.01515 Log(Pump)

As all of the estimated coefficients for the model are now not only statistically significant, but also the best linear unbiased estimators. The model result, thus, can be used to estimate the total factor productivity index and its contribution to the output growth.

Appendix 2:

Trend of Land, labor productivity, input and output for Vietnam Agriculture

Year	Land Productivity (Mill.Dong/ha)				Labor Productivity (Mill.Dong/labor)				Land-Labor Ratio (Ha per labor)			
	North	Central	South	Country	North	Central	South	Country	North	Central	South	Country
1985	8.181	9.025	6.515	7.424	2.901	3.298	3.614	3.290	0.355	0.365	0.555	0.443
1986	8.521	9.178	6.974	7.798	2.985	3.245	3.770	3.378	0.350	0.354	0.541	0.433
1987	9.009	9.238	6.723	7.817	3.103	3.101	3.463	3.259	0.344	0.336	0.515	0.417
1988	8.922	9.233	7.380	8.137	2.970	2.996	3.763	3.320	0.333	0.324	0.510	0.408
1989	9.377	9.957	8.013	8.726	2.917	3.189	4.175	3.502	0.311	0.320	0.521	0.401
1990	9.577	9.877	8.148	8.840	2.891	3.099	4.215	3.488	0.302	0.314	0.517	0.395
1991	9.010	9.880	8.870	9.072	2.586	2.776	4.532	3.414	0.287	0.281	0.511	0.376
1992	10.626	10.122	8.665	9.435	2.914	2.761	4.607	3.565	0.274	0.273	0.532	0.378
1993	12.034	10.211	8.953	9.986	3.026	2.642	4.576	3.571	0.251	0.259	0.511	0.358
1994	12.497	11.245	9.363	10.451	2.887	2.713	5.031	3.687	0.231	0.241	0.537	0.353
1995	13.383	11.440	10.209	11.186	2.856	2.627	5.334	3.769	0.213	0.230	0.523	0.337
1996	13.331	11.305	10.400	11.260	2.977	2.610	5.828	3.990	0.223	0.231	0.560	0.354
1997	14.304	12.373	10.679	11.798	3.098	2.832	5.985	4.157	0.217	0.229	0.560	0.352
1998	14.961	12.411	10.650	11.894	3.168	2.782	6.271	4.273	0.212	0.224	0.589	0.359
1999	15.954	13.539	11.379	12.739	3.336	3.073	6.559	4.530	0.209	0.227	0.576	0.356
Max	15.954	13.539	11.379	12.739	3.336	3.298	6.559	4.530	0.355	0.365	0.589	0.443
Min	8.181	9.025	6.515	7.424	2.586	2.610	3.463	3.259	0.209	0.224	0.510	0.337
Aver	11.312	10.602	8.862	9.771	2.974	2.916	4.782	3.679	0.274	0.280	0.537	0.381

(Table continued)

Year	Agricultural Gross Output (Bill.D at 94 prices)				Agricultural Land (1000ha)				Agricultural Labor (1000persons)			
	North	Central	Sourth	Country	North	Central	South	Country	North	Central	Sourth	Country
1985	16531	10587	24423	51541	2021	1173	3749	6942	5699	3210	6758	15667
1986	17363	10692	26120	54175	2038	1165	3745	6948	5816	3295	6928	16039
1987	18500	10685	25153	54337	2053	1157	3741	6951	5962	3446	7263	16671
1988	18195	10568	27841	56604	2039	1145	3773	6956	6126	3527	7398	17051
1989	19042	11276	30508	60826	2031	1133	3807	6970	6527	3536	7308	17371
1990	19420	11074	31323	61818	2028	1121	3844	6993	6717	3574	7432	17723
1991	18356	11044	34112	63512	2037	1118	3846	7001	7097	3978	7527	18602
1992	21642	11283	35896	68820	2037	1115	4143	7294	7426	4086	7792	19304
1993	24241	11258	37881	73381	2014	1103	4231	7348	8011	4262	8278	20551
1994	23911	12092	40995	76998	1913	1075	4379	7367	8281	4457	8148	20886
1995	24693	12396	45218	82307	1845	1084	4429	7358	8646	4718	8477	21840
1996	25463	12540	48486	86489	1910	1109	4662	7681	8553	4805	8320	21678
1997	27143	13835	51552	92530	1898	1118	4827	7843	8761	4885	8613	22259
1998	28008	13934	54160	96103	1872	1123	5085	8080	8842	5009	8637	22488
1999	29868	15200	57864	102933	1872	1123	5085	8080	8953	4947	8823	22723
Max	29868	15200	57864	102933	2053	1173	5085	8080	8953	5009	8823	22723
Min	16531	10568	24423	51541	1845	1075	3741	6942	5699	3210	6758	15667
Aver	22158	11898	38102	72158	1974	1124	4223	7321	7428	4116	7847	19390

(Table continued)

Year	Cropping Intensity Ratio				Fertilizer per AgriLand (Kg/ha)				Tractors per AgriLand (pieces/thousand ha)			
	North	Central	Sourth	Country	North	Central	Sourth	Country	North	Central	Sourth	Country
1985	1.33	1.58	1.07	1.23	82	60	55	64	2.5	2.5	6.4	4.6
1986	1.31	1.53	1.11	1.24	116	75	76	87	2.0	2.6	6.3	4.4
1987	1.34	1.54	1.10	1.24	102	57	50	66	2.2	2.3	4.1	3.3
1988	1.39	1.56	1.13	1.28	102	69	90	90	2.2	2.4	3.9	3.2
1989	1.39	1.54	1.16	1.29	79	89	73	77	2.1	1.7	4.2	3.2
1990	1.36	1.55	1.19	1.29	114	70	73	84	2.1	2.6	4.7	3.6
1991	1.38	1.57	1.26	1.34	141	109	131	130	3.5	3.7	6.3	5.1
1992	1.42	1.64	1.22	1.34	166	72	105	117	3.5	3.3	6.5	5.2
1993	1.46	1.64	1.25	1.36	189	52	79	105	4.1	3.4	8.0	6.2
1994	1.52	1.69	1.29	1.41	239	87	117	145	8.5	7.3	14.8	12.1
1995	1.59	1.69	1.30	1.43	218	68	113	133	10.1	7.5	16.0	13.3
1996	1.54	1.69	1.31	1.42	299	82	155	181	11.4	8.9	16.9	14.4
1997	1.60	1.70	1.32	1.44	324	103	159	191	11.6	9.8	17.1	14.7
1998	1.66	1.72	1.32	1.45	401	121	182	224	11.9	10.5	17.5	15.2
1999	1.70	1.78	1.40	1.52	436	133	195	242	13.1	12.3	21.1	18.0
Max	1.70	1.78	1.40	1.52	436	133	195	242	13.1	12.3	21.1	18.0
Min	1.31	1.53	1.07	1.23	79	52	50	64	2.0	1.7	3.9	3.2
Aver	1.47	1.63	1.23	1.35	200	83	110	129	6.1	5.4	10.3	8.4

Source: GSO, MARD and Authors' calculation.
*Note: * Annual growth rate is a smoothed (three-year moving average) compunding growth rate*

The Role of Agriculture in Vietnam's Economy

	Unit	1995	1996	1997	1998	1999
Labor Force,	1000 persons	38815	39839	41025	42188	43545
Agricultural Sector	1000 persons	24771	24844	25548	25844	26168
Share	%	63.8	62.4	62.3	61.3	60.1
GDP	Bill. D at 94 price	195567	213833	231264	244596	256269
Agricultural Sector	Bill. D at 94 price	51319	53577	55895	57866	60893
Share	%	26.2	25.1	24.2	23.7	23.8
Export, Million US$	Mill. US$	5449	7256	9185	9360	11520
Agricultural Sector	Mill. US$	2521	3068	3239	3324	3949
Share	%	46.3	42.3	35.3	35.5	34.3

Source: GSO