

Agricultural Productivity Growth, Rural Economic Diversity, and Economic Reforms:
India, 1970-2000

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A salient theme in D. Gale Johnson's work is the importance of agricultural development for general prosperity and for economic diversification (e.g., Johnson, 2000). Johnson has also noted that most of the world's poor are engaged in farming, so that a key focus of development policy is to raise the incomes of farmers. From a global perspective, increasing the productivity of agriculture, given the fixity of land, is necessary for both poverty reduction and the development of the non-agricultural sector. At the level of the world, agricultural productivity gains, poverty reduction and the growth of the non-farm sector are complements. However, the question remains whether these observations imply that every poor country should focus its public resources on agricultural development in order to raise the incomes of people now engaged in farming and whether such a policy is necessary for obtaining economic diversity.

In this paper we use the experience of India over the past 30 years to address the issue of whether agricultural technical change actually leads to economic diversification and income growth within the rural sector in the context of an open-economy country in which there is cross-area trade and capital flows. We focus in particular on the rural sector because this is the sector in which linkages between agricultural and non-agricultural sectors are thought to be the most strong. We exploit the fact that India has maintained a policy of openness with respect to agricultural technology over this period, permitting and actively supporting agricultural development, and has moved to a reformed regime in which goods are traded and capital is more mobile in the 1990's.

Evidence on the relationship between agricultural growth and non-farm growth has been

mixed at the country level, mostly due to data limitations.¹ Moreover, most empirical studies lack a theoretical framework and, in particular, treat the rural, non-farm sector as homogeneous, ignoring the distinction between traded and non-traded non-farm goods that is relevant to open economies. We use newly-available survey data covering the major states of India over the past thirty years within the context of a general-equilibrium framework to look descriptively at the effects of yield improvements associated with the green revolution on rural non-farm activities, incomes and enterprises distinguished by whether they are in non-traded (locally financed) or traded sectors with spatially mobile, non-local capital. India has experienced over this period significant increases in crop yields and a substantial expansion, especially in the last twenty years, in both rural per-capita incomes and in rural diversification, with now almost half of rural incomes coming from outside the farm sector. This would appear to be consistent with the hypothesis that agricultural and non-agricultural development are complements. However, using times-series of over 240 villages covering most of India, we find that in fact the rapid growth in rural industry occurred in areas with the lowest rates of improvements in crop yields, consistent with a model in which industrial capital is mobile and seeks low-wage areas. Given this mobility, within the country rural industrialization and agricultural development are substitutes.

Section 1 of the paper briefly describes the general-equilibrium framework we use to examine the data. Section 2 describes the data and presents descriptive statistics on the trends in agriculture and the rural non-agricultural sector in the past 30 years as well as the impact of high-

¹For example, Ravallion and Datt (1996, 1999) using a state-level data set from India that combines multiple national-level cross-sectional household surveys with state-level aggregate data on sectoral income does not find strong evidence that agricultural growth increases non-agricultural growth. However, an important limitation of their data is that non-farm income is not available from their data sources separately for rural and urban areas.

yielding-variety (HYV) crop yield improvements on the agricultural sector, including effects on land prices, land improvements and agricultural land and non-land wealth. In section 3, descriptive evidence in graphical format is adduced that shows the relationship across India between crop yield growth rates in the pre- and post-reform periods and changes in income by source, changes in the activities of male labor by sector, wealth by source, and the placement of factories and local service-sector enterprises. The relationship between initial conditions in 1971 and subsequent agricultural and rural industrial development is also examined. The patterns suggest that agricultural development occurred in the less advanced area of India but that industrial activity grew in the more developed areas, leading to misleading inferences from cross-sectional comparisons that are prevalent in the literature. Section 4 presents descriptive regressions that quantify the relationships between agricultural incomes, factory location, non-farm wage incomes, local business incomes and HYV crop yields, and compares cross-sectional with over-time estimates that control for fixed differences across India villages. The empirical results indicate that cross-sectional estimates are biased positively, overstating the positive relationship between crop yield growth associated with the green revolution and agricultural incomes, and obscuring the strong negative relationship between such development and the growth in rural industry. The results also show that locally-oriented, locally-financed businesses grew little over the entire period and were not significantly affected by local agricultural development. Section 5 contains a conclusion.

1. Framework

To characterize the process of economic diversification and how it is influenced by growth in agricultural productivity we develop a theoretical framework that incorporates three

distinct sectors. Agricultural and manufactured goods are assumed to be traded across space whereas local services such as those provided by tailors, shopkeepers and builders are consumed and produced locally. Household consume agricultural, manufactured and service goods and allocate their labor to farming their own-land, running a non-farm business, and as wage workers in the available sectors. Income is consumed, invested locally in farm or non-farm capital, and saved through financial intermediaries, if available. Labor is immobile and labor markets are competitive with wages equilibrating within the village across the different sectors of the economy. The agricultural technology is increasing in land, labor, and capital and an exogenous productivity factor that varies across space and time. The non-traded service technology is increasing in labor and capital and is assumed to be dominated by owner operated small businesses. Initially, it is assumed that local production is restricted to the agricultural and service sectors so that all manufactured goods must be imported. Subsequently, we consider the implications of opening up the village economy to the entry of rural manufacturing that is financed by mobile external capital, produces goods that may be traded externally, and employs local labor.

In the absence of rural manufacturing, growth in the non-farm sector will depend importantly on the income elasticity of demand for local non-tradeables. If non-farm services are inferior then growth in agricultural productivity may result in an expansion of manufactured imports and a decline in the non-farm sector. Otherwise, expansions in rural agricultural productivity will increase demand for non-traded services and possibly generate capital that can be used for non-farm investment. But even in this case it is unclear that there will be an expansion in employment in the non-farm sector. This depends on the factor intensity of

productivity growth in agriculture and the shares and substitutability of labor and capital in the two sectors. There are two offsetting effects. On the one hand, given that agricultural goods can be exported in exchange for manufactured goods and that total land is fixed, agricultural productivity growth tends to push up the demand for agricultural labor, thus increasing wages and agricultural employment. On the other hand, this growth expands incomes which, given income-elastic demand for non-traded goods, increases the price of non-traded services and thus the demand for labor in the non-traded sector.

With the entry of mobile factory capital the effects of agricultural productivity growth change markedly because this capital will seek out low wage areas, producing and exporting manufactured products from these areas to areas where manufacturing is more costly. Because productivity-driven increases in agricultural labor demand will tend to push up wages, factory capital and thus factory employment will tend to grow in those areas with low growth in agricultural productivity. This means not only that the non-farm sector is likely to be decreasing in agricultural productivity but also that the effects of agricultural productivity growth on income and wage growth will be dampened. This, in turn, has implications for inequality. Entry of mobile factory capital will tend to reduce the inter-village inequality that tends to emerge from differences in agricultural productivity growth across villages. Conversely, agricultural productivity growth will create greater inequality relative to the non-factory case if there is inequality in land because wages will not rise as fast as land rents when agriculture becomes more productive.

2. Data and Trends in Agricultural and Non-Agricultural, Rural Development: 1971-99

To assess how agricultural development affects the composition of rural activities and

incomes, we use a series of household data sets from India covering the period 1971-1999. India is a particularly good setting for examining how agricultural technical change affects development. First, Indian village economies in part mimic small countries in that permanent migration between villages is relatively small, so that wages and thus incomes are determined by village demand conditions, including local agricultural technical change, and local supply characteristics (Foster and Rosenzweig, 2003), while agricultural prices are set nationally by the central government. And, although industry has been regulated, entrepreneurs are able to establish factories wherever they wish across India, so that factory capital is mobile. Second, there has been substantial improvements in agricultural productivity associated with the green revolution starting in the late 1960's - due to the importation of new, high-yielding seeds and public investment in seed development (Evenson and McKinsey, 1999). The Indian green revolution thus reflects active government policy, to lift restrictions on specific imports and to support both technical development, dissemination and distribution of complementary inputs. The growth in agricultural productivity has varied widely across India due to natural soil and water conditions as well as, in part, governmental intervention.

The data we use characterizes households living in 240 villages in the 16 largest states of India based on a continuing survey of rural households that began in 1968 and has been carried out by the National Council of Applied Economic Research (NCAER). The first round of the survey for which there is complete village and household information, in 1971, includes 4,527 households in 259 villages and is meant to be representative of the entire rural population of India residing in the 17 major states. In 1982, 250 of the original 259 villages were revisited (the state of Assam was excluded) and 4,979 households surveyed, approximately two-thirds of

which were the same households as in the 1971 round. In 1999, all of the 1971 villages were surveyed, but excluding the eight sample villages in Jammu and Kashmir. In this latest survey round, all of the surviving households in the 1982 survey were surveyed again, including for the first time all split-off households residing in the same villages, plus a small random sample of new households. Because of household division and the new sample design incorporating all village-resident male 1982 surveyed household members, the number of households in the 1999 round increased to 7,474. Given the sampling strata, each of the survey rounds characterizes the populations in each of the sampled villages so that it is possible to construct a panel of villages for the 1971-99 period for 240 villages in 15 states. The data sets in all years provide information on agricultural yields by seed type and crop, on infrastructure and industry, and on wages and prices at the village level; on incomes and assets, by source, at the household level; and on activities, by sector, at the individual level. We also appended to the data information on rainfall, obtained from the monthly time-series available from 40 Indian weather stations, using our geocoding of the villages and weather stations to compute nearest-station rainfall measures for the villages.

The key variable in any exploration of the effects of agricultural development is a measure of agricultural technical change. Prior studies have used adoption rates of high-yielding variety (HYV) seeds. However, adoption choices reflect in part the returns to land, capital and labor in alternative uses. To examine how agricultural development affects sectoral activities, we constructed from the village-level data on prices, seed types and yields an index of HYV seed yields on irrigated lands for each village for each of the three survey years using a Laspeyres-weighted (1971 prices) index for four HYV crops - corn, rice, sorghum and wheat. This measure,

based on estimates from informed sources in each village, represents at each survey date the village-specific maximum yield local farmers could obtain, and controls for a key determinant of yield, irrigation and which itself responds to HYV seed development. Figure 1 displays the max HYV yield index for the three sample years. As can be seen, the index of HYV yields on irrigated land rose by 86% between 1971 and 1982 and by 74% between 1982 and 1999. Clearly there has been substantial agricultural yield growth from 1971 through 1999, but the annual rate of increase in yields for these crops slowed down in the latter two decades.

For the purposes of analyzing the associations between agricultural technical change and development, we divided up the villages into five groups according to the growth rates in the max HYV yield index over the 1971-99 period. Figure 2 depicts the distribution of growth rates by quintile. As can be seen, the differences in yield growth rates across areas are substantial - yield growth in the top quintile is almost seven and a half times that in the bottom quintile. The growth rates in yields had substantial effects in the agricultural sector over the period. For example, the growth rates in HYV yields were associated strongly with increases in real land wealth, as shown in Figure 3. In the bottom two quintiles of the HYV yield growth distribution, land values, relative to the consumer price index, rose by 68%, while in the top three quintiles land values increased tenfold.

Some of the relative increase in land values was due to rising land prices induced by agricultural productivity increases. Figure 4 shows the prices of unirrigated and irrigated land in 1971 and 1999 in each of the HYV yield-growth quintiles. The prices of both types of land clearly rose more in the higher-yield growth areas. Some of the rise in land values was also due to irrigation investment, however. Figure 5 depicts the share of irrigated land in 1971 and 1999

for each of the five quintiles of the HYV yield growth distribution. In the bottom quintile, there was essentially no overall increase in the share of irrigated land from its 64% value, while in the top quintile the share rose from 17% of total arable land in 1971 to 50% in 1999. Figures 4 and 5 also display an interesting feature of the green revolution experience in India. HYV yield increases over the 1971-99 period were inversely related to the initial 1971 distribution of both land quality (as reflected in land prices by irrigation status) and irrigated land shares. Thus, those areas most developed in terms of agriculture in the initial period experienced the lowest subsequent advances in HYV crop yields over the next 28 years. Evidently as a consequence, the proportions of irrigated crop-land across villages and land prices were substantially more equal in 1999 than they were in 1971. The strong inverse relationship between yield growth and initial agricultural productivity, and possibly other aspect of development, means that inferences about the role of agricultural development in fostering growth in non-farm activities in India based on cross-sectional analyses can be misleading. We will consequently look at how changes in HYV yields are related to changes in measures of agricultural and non-agricultural, rural development.

What happened to incomes and activities over the 1971-1999 period? Figure 6 displays the average per-capita incomes of the households, in 1982 rupees, in the three survey rounds by income source. As can be seen, in the 1971-1982 period there was little change in per-capita income. This was still an impressive accomplishment, however, as the population size of the villages expanded on average by 37%. During this period of agricultural development there was also a significant increase in the share of total non-farm income in total income, from 19.3% to almost a third. However, none of this increase was in the form of local non-farm enterprise or business income. Rather wage and salary incomes more than doubled. In contrast, in the 1982-

1999 period, per-capita incomes increased by 70% while population grew by 47%. And the share of non-farm incomes in total rural income rose to almost half by 1999 (48.1%). Again, all of the increase in non-farm incomes was in the form of wages and salary.

Examination of the primary activities of young males aged 25-44 and the asset portfolios of the households reveals the same patterns. Figure 7 shows that there was an expansion of non-farm activities by the young men over the whole period 1971-1999 period, but mainly in activities providing wages or salaries, not non-farm business income. In 1971, 82% of men aged 25-44 reported that their primary activity was either farming or earning agricultural wages; by 1982 this proportion had dropped to 73% and by 1999 the proportion working in agriculture as a primary activity was only 53%. Between 1971 and 1982, the fraction of men in the age group working for wages or salary outside the agricultural sector rose from 10% to 16%; between 1982 and 1999 that proportion had more than doubled, to 36%. In the same time periods, the fraction listing non-farm business as a primary activity went from 3% to 6% to only 7.5%. Increases in local enterprise activity may be understated by the distributions of primary activities, if such activities are engaged in as a secondary occupation by many workers. However, the lack of local business activity and development over the period is also seen in the income shares shown in Figure 6 and in the changes in the non-land asset distribution, depicted in Figure 8. Although the total value of non-land assets rose over the whole period, assets associated with local businesses remained stagnant in real terms. The largest growth occurred for housing and for financial assets, neither of which contributes to local business activity other than house construction.

Given the slow-down in yield growth, seen in Figure 1, some other forces must have been in play in the 1982-99 period in the rural sector so that real incomes and non-farm incomes in

particular rose. Indeed, during this 17-year period there was a substantial expansion of factory employment. In 1982 only 17% of villages had individuals employed in factories, while in 1999 more than half of the villages had employees in factories. Moreover, the average number of factory workers per village in 1982 was 5.7; by 1999 factory employment had grown to 57 workers per village. This tenfold increase in factory employment between 1982 and 1999 may have been an important factor in raising non-farm incomes. The question we address below is whether and how factory expansion was related to agricultural technical change. Whatever the relationship, local business development was not a major part of non-farm activity expansion - the number of local, service-oriented establishments per village actually declined over the 1982-99 period, from an average of 36.2 per village to 33.2.²

Other factors that may have affected the composition of employment and incomes by sector between 1971 and 1982 include financial development and the growth of towns. Figure 9 depicts the proportion of villages with a post office, an important instrument for savings in rural India, and a commercial bank for the three survey years. As can be seen, there was a rise in village coverage of financial institutions. 62% of villages had a post office in 1971, but over 90% had a post office in 1999. Similarly, just over 10% of villages had a bank in 1971, while 32% had one in 1999. There was also a significant rise in towns in the 1982-99 period, as depicted in Figure 10. Although the proportion of villages less than 10 kilometers from a town remained at around 30% in 1971 and 1982, by 1999 47% of the villages were proximate to a town.

3. Descriptive Evidence

²The 1971 data do not provide information on the number of establishments or on factory employment. Villagers were employed in factories in only 10% of villages in 1971.

Income and activity by sector

In order to obtain a relatively complete picture of the consequences for the rural non-farm sector of growth in agricultural productivity we examine a series of sector-specific measures inclusive of income, capital, primary activity, and overall employment, stratified by year and the quintile-based spatial division of 1971-1999 productivity growth in agriculture. We first consider sector-specific income growth, which gives a comprehensive picture of the relevance of particular types of activity at the level of the household to expansion in income.

The relationship over the period between household income by sector and crop yield growth does not support the hypothesis that non-farm growth is importantly tied to expansion in the agricultural sector. Specifically, Figure 11 shows that, as a share of total income, non-farm income growth was actually highest in the low yield growth quintiles.³ In the high yield growth quintiles the non-farm income share increased only 14 percentage points from 26% in 1971 to 40% in 1999. By contrast, in the lowest growth category the non-farm income share increased by 33 percentage points, from 21% in 1971 to 54% in 1999. This provides evidence consistent with our framework in which growth in the non-farm sector is importantly linked to a low opportunity cost of labor and thus the absence of agricultural productivity. However, this evidence is somewhat limited in that the non-farm sector here combines both the non-traded and traded components, which are framework suggests should be affected in opposite ways by productivity growth in agriculture. Moreover, given the use of income shares, this graph is consistent with the

³Unless otherwise qualified, the phrases “low growth areas”, “lowest growth category”, and lowest quintile refer to the villages in the lowest 20% of HYV-crop yield growth measures over the 1971-1999 period and “high growth areas”, “highest growth category”, or “highest quintiles” refer to the villages with the highest 20% of HYV-crop yield growth in this period.

presumption that there has been little differential change in non-farm activity by agricultural productivity growth so that differences in shares in total income are primarily driven by differences in growth in agricultural income.

Figure 12, which presents the two components of non-farm income, provide further evidence to support the view that agricultural development has different effects on non-farm activity given capital mobility. It is clear, first of all, that total non-farm income increased markedly in each of the five yield growth quintiles, with the largest increases accruing in the lowest productivity growth groups. In real terms total non-farm income grew by a factor of almost 5 from 1029 to 5102 Rs per annum in the lowest quintile. By contrast in the highest quintile, non-farm income grew from a slightly higher initial level, Rs 1154, to Rs 3335, which is a factor of only 2.9. More importantly, most of this growth and essentially all of the differential growth in non-farm income came from the non-farm earning sector. Non-farm business earnings growth was 66% in the lowest yield growth quintiles and 39% in the highest yield growth quintiles. By contrast, growth in non-farm employment earnings was 824% in the low-growth villages and 366% in the high-growth villages. Thus, consistent with our framework, the primary source of the expansion in non-farm income was growth in the non-farm labor market, rather than in self-employment, and this expansion was highest in the low productivity growth areas.

Interestingly, an analysis based on differential growth in non-farm income by initial agricultural productivity would have yielded a very misleading picture of the relationship between agricultural productivity and the non-farm sector. Figure 13 is comparable to Figure 12, but is stratified by initial agricultural productivity in 1971 rather than crop productivity growth between 1971 and 1982. Given the results from Figure 12 and the overall negative correlation

between productivity growth and initial productivity level, it should not be surprising to see that total non-farm income growth is highest in the high-productivity areas in 1971 and that growth, in particular, in employment earnings is increasing in 1971 productivity. Thus a researcher who mistakenly believed that productivity in 1971 was a good proxy for productivity growth in the subsequent 30 years might erroneously conclude that growth in non-farm employment is increasing in agricultural productivity growth.

One limitation of examining changes by sector in income by source is that they are influenced by changes in factor prices as well as by changes in the allocation of time. Although the panel data do not contain detailed information on the allocation of time by household workers, reports of primary activity can be informative about how time is allocated. Figure 14 plots the share of men aged 25-44 by year and agricultural productivity growth for the two non-farm activities, non-farm wage work and non-farm business. The results are consistent with those presented by income, with overall growth in the share of men reporting a non-farm principal activity being somewhat higher in the low-growth areas and with this contrast being substantially stronger when limiting attention to non-farm wage employment. In particular, there was a 39 percentage point rise in this measure of total non-farm activity in the lowest yield growth quintile and only a 28 percentage point rise in the highest yield growth quintile. Within the non-farm wage sector, by comparison, the rise in activity in the lowest growth area of 45 percentage points is almost twice the rise of 23 points observed in the highest growth areas. Conversely, business activity rose by 12 points in the highest growth villages but only 5 points in the lowest growth villages.

Establishments

Although household-level data permits a distinction to be drawn between family employment and non-farm employment earnings in households, it provides an incomplete picture of the labor market and, in particular, the source of the expansion in non-farm employment. This issue can be addressed through an examination of village-level data on enterprises that is available in the panel data set and clearly supports our contention that the expansion in non-farm employment is primarily due to growth in rural industry. Figure 15 plots the proportion of villages with at least one factory by year and yield growth category. In the two lowest agricultural productivity growth quintiles, the share of villages with a factory rose from just over 10% to approximately 50%. By contrast, in the three high-productivity growth quintiles there is little systematic change over time in the presence of factories. Indeed, in the highest yield quintile the fraction of villages with a factory fell from 20% to 12% over the 1971-1999 period.

While factory employment data are not available in 1971, both 1982 and 1999 enumerated employment of village workers by factories in the village or in neighboring villages. These data, presented in Figure 16, also illustrate the dramatic expansion of the factory sector over this period, particularly in low-growth areas. Specifically, the number of factory workers per village in 1982 was roughly 5, regardless of the level of productivity growth over the 1971-1999 period. By contrast, factory employment averaged 48.9 in the lowest yield growth quintiles, an increase of more than 10-fold. While growth in factory employment in the high growth quintiles was also substantial, it was less than half of that in the lowest growth quintiles, rising from 4.8 to 22 workers on average.

Similar village data on the number of local service enterprises were also collected in 1982 and 1999 and, in comparison with the results from Figure 16, provide evidence consistent with

the framework presented above in which the non-tradable and mobile capital sectors are affected in opposite ways by agricultural productivity growth (Figure 17). In particular, the number of service enterprises per village decreased by 14 and 36 percent in the two low-growth categories while increasing by 31, 17 and 25 percent in the three high-growth categories. Unfortunately, a time series of employment data is not available; however, evidence from 1999 indicates that these enterprises tend to be quite small, with 2-3 workers on average. Based on these averages, low yield growth villages lost 20-40 service jobs in the 1982-99 period while high growth villages gained approximately 10 workers. This differential is roughly comparable in magnitude but of opposite sign to the differential in factory employment growth by agricultural productivity growth observed in Figure 16.

Effects of capital

One as yet unaddressed component of the agricultural-led growth thesis is that agricultural productivity growth produces incremental profits which may then be used to finance investment in non-farm capital. Patterns of non-farm income growth and primary activity suggest, as posited in our model, that growth in non-farm self-employment has played a relatively minor role in terms of the overall expansion in non-farm activity and thus indicate that this sector is not a significant destination for newly generated capital. The finding that factory growth is highest in the low-yield growth quintiles provides further evidence against the proposition that local generation of capital plays an important role as an engine of growth for local non-farm activity. More direct evidence, however, comes from an examination of how productivity of growth in agriculture affects the composition of wealth.

The data on wealth holdings clearly do not support the hypothesis that expansion in

agricultural productivity releases capital for use in local non-farm investment. Figure 18 shows that total wealth is dominated by land wealth and that growth in the value of land is highest in the high growth areas. In 1971, there was relatively little variation by level of growth in agricultural productivity in the share of land wealth, with the shares in all but the highest growth areas being above 70% and the share in the highest growth area only slightly lower at 66%. Between 1971 and 1999, however, land wealth grew by a factor of 15 in the high growth areas while only growing by a factor of 2.3 in the low productivity areas so that land wealth shares were 90% and 57%, respectively.

While the finding that the share of non-land wealth declined in high-growth villages does not necessarily imply that capital for non-farm investment in high growth areas was not expanding, there is a sound theoretical reason to expect this decline. Given diminishing marginal returns to wealth, the rapid gains in land wealth enjoyed by landed households in the high growth will *ceteris paribus* cause households to reduce wealth holdings in other areas, not expand them as implied in the agriculturally-lead growth thesis. Figure 19 shows clearly that, in fact, growth in non-agricultural wealth was decreasing in agricultural productivity growth: while average non-agricultural wealth grew by Rs 27,358 in the lowest-growth category, it grew by less than half of that, Rs 13,411, in the highest-growth category. It is also evident from Figure 19 that the house constituted the major source of non-agricultural wealth holdings and that capital is of minimal importance in terms of the growth of the one component of the non-farm sector that responds positively to agricultural productivity, the self-employment sector. There is thus no evidence to support the hypothesis that growth in agricultural productivity releases capital that is then invested in the local economy in the form of small business. Nor is there support for the alternate

view that capital generated through agricultural productivity growth enhances non-farm growth elsewhere. Financial assets growth (Rs 2399) over the 1971-1999 in the lowest productivity areas is almost twice the growth of financial assets (Rs 1353) in the highest growth areas.

Proximity to town

The descriptive results presented thus far provide a strong case against the thesis that increases in agricultural productivity are a major engine of growth in the non-farm sector. But it is useful to consider other possible factors influencing the growth of the factory sector with a view towards better understanding the process of economic diversification and due to possible mistaken inferences that might arise if these other factors are correlated with agricultural productivity growth. A natural factor to consider in this regard is proximity to an urban center or town. Such proximity may influence factory growth for a variety of reasons. If transportation costs are non-negligible and urban centers are either a major source of demand for the products of rural factories or provide key intermediate inputs then factories may find it impractical to locate themselves in isolated areas, even those areas with very low wages. The density and quality of the labor force may be different within urban areas, either promoting or discouraging location of factories in these areas. There is also a reasonable case to be made that the growth of towns is influenced by many of the salutary conditions that also predispose an area to productivity growth in agriculture.

Figure 20 presents the proportion of non-farm income in total income by proximity to town, where proximity to the nearest town is measured in terms of categories based on the quintiles of the distribution of distance to town in the sample villages. There is some evidence of differential proportionate growth in the non-farm sector. In the areas closest to a town there was

an increase in the share of income due to the non-farm sector from 21% to 54%, a rise of 33 percentage points. By contrast, the rise in the non-farm sector fraction in the most distance area was only 22 percentage points. Not only are these differences substantially smaller than those observed when stratifying by agricultural productivity growth (Figure 11) but they also seem to be distributed equally between the employee and business components of non-farm employment. In particular, over the 1971-1999 period there was a 32 and 30 point rise, respectively, in the share of non-farm income attributed to employee income in villages closest to a town as compared to that in villages that are distant from the nearest town (Figure 21). Thus although any correlation between distance to town might partially explain the relationship between productivity growth and total non-farm income, it cannot explain the different effects of productivity growth on employee and self-employment income. We explore this issue in greater detail in Section 4.

4. Econometric Estimates

In this section we obtain econometric estimates of the relationship between yield growth and changes in non-farm income by source, net of trends related to proximity to towns. In addition we estimate the relationship between yields and factory presence. Based on the survey data in each survey round, we constructed for each village and year per-household agricultural income, wage and salary income and business income. The equations we estimate are:

$$(1) \quad y_{it} = \beta_1 HYV_{it} + \beta_2(\text{year}=1971) + \beta_3(\text{year}=1982) + \beta_4 \text{town71}^*(\text{year}=1982) + \beta_5 \text{town71}^*(\text{year}=1999) + \mathbf{Z}_{it}\beta + \mu_i + e_{it},$$

where y is the outcome variable for village i and year t , HYV =the log of the HYV yield index, town71 =a dummy variable indicating whether the village was located within 10 kilometers of a

town in 1971, the Z-vector contains other variables that may affect the dependent variable, μ_i is an unobserved village-specific fixed-factor, and e_{it} is an i.i.d. time-varying error term. The coefficients β_2 and β_3 capture period effects common to all villages and the coefficients β_4 and β_5 reflect period-specific trends in incomes and factory presence associated with initial town proximity.

We have seen evidence that villages differed in their level of development in the initial period and that villages with initially higher yields also had a more developed non-farm sector in the initial period. This would induce an upward bias in the coefficient β_1 . To eliminate this source of bias we estimate (1) using fixed effects. Thus, all FE estimates of yield effects are identified from the relationships between changes in yields (induced by technical change) and changes in the outcome measures.

The first column of Table 1 reports the GLS estimates of (1) for the log of total agricultural income (farm income plus agricultural wage income). As would be expected, the estimates indicate that higher yields are associated with higher agricultural incomes and that agricultural incomes are also higher in villages located closer to organized agricultural markets (*mandis*). A peculiar finding, however, is that total rainfall in the crop year, as well as rainfall in March, have negative effects on crop income. The fixed effects estimates in columns two and three indicate that the former result is spurious. Once fixed factors associated with climate are swept out, total annual rainfall has the expected positive effect on agricultural income. The FE yield estimate is only slightly smaller than the GLS counterpart, however, indicating that a doubling of HYV yields raises agricultural incomes by 21%. In the third column, the initial proximity to towns and financial infrastructure variables are added. These have no effect -

agricultural incomes, net of yield growth, did not grow more in villages initially close to towns or because of the presence of formal credit institutions. The time dummy variables indicate, however, that net of yield improvements, agricultural incomes are lowest in the post-reform 1999 period and highest in 1971. This is consistent with the growth in non-farm employment opportunities, which raises labor costs, occurring in the 1980's and 1990's.

The estimates in Table 1 clearly indicate that moving the yield growth frontier increases agricultural incomes. Does yield growth also increase local non-agricultural incomes? Table 2 reports GLS and fixed-effects estimates of the relationship between agricultural yields and the presence of a factory in the village, the log of non-farm wage income and the log of business income. The estimates of the yield effects based on the cross-sectional relationships suggest that higher yields are associated with both higher non-farm wage and local business income. However, these estimates appear to be substantially upward biased due to a correlation between local development and yields. When the fixed-effect is removed the estimates indicate, consistent with the figures based on yield growth, that an increase in crop yields reduces the probability that a factory employs individuals from the village and decreases the level of non-farm wage income. These results are consistent with a framework in which non-farm capital is mobile and seeks low-wage areas, so that agricultural development and non-farm activities are substitutes rather than complements. Agricultural development also appears to have only a negligible effect on local non-farm business income. In particular, the fixed-effects point estimates suggest that a doubling of yields reduces the probability of a factory locating in a village by 40% (using the 1982 mean), reduces non-farm wage income by 25% and only increases non-farm business income by a statistically insignificant 11%. The competition, rather than the complementarity,

between agricultural and non-agricultural activities is also seen in the time dummy variables - local factory presence and non-farm wage incomes are significantly higher, given crop yields, in 1999 compared to 1971, while from Table 1, we saw that agricultural incomes were significantly lower in the post-reform period. Finally, none of the estimates indicate that initial proximity to towns has any effects on non-farm activities.⁴

The fact that agricultural productivity improvements did not lead to increases in non-farm incomes where they occurred, and indeed, led to decreases in non-farm incomes, does not mean that investments in agricultural technology do not payoff. Table 3 reports GLS and Fixed-effects estimates of the associations between yield rates and the log of total household income. Again, the GLS, cross-sectional estimate of the crop yield effect is evidently upward-biased. The fixed-effects estimate of the yield effect, however, is still positive, but modest in size - indicating that a doubling of agricultural yields in an area raises total incomes by only 5%, compared to raising average agricultural income by over 20% (Table 1). The difference is evidently due to the mobility of non-agricultural capital. The net beneficial effects of overall non-farm employment growth on total incomes is seen in the period dummy coefficients. Total incomes are 30% higher on average in 1999, net of yield improvements, compared with 1971 and 38% higher than in 1982, corresponding roughly to the trends in factory presence and the growth in non-farm wage incomes seen in Table 2.

5. Conclusion

Although the success of the Green Revolution in India and around the world in raising

⁴Neither the financial institution nor rainfall variables have any statistically significant effect on the dependent variables in Table 2.

rural incomes and reducing rural poverty by increasing agricultural productivity is widely acknowledged, there is also recognition that a single-minded focus on enhancing productivity growth in agriculture as a source of welfare enhancement in rural areas is likely to be counterproductive in the context of a global economy. Not only is increased global food productivity likely to result in decreased global prices and thus lower returns to poor farmers, but also there are substantial regions of the world where poor climate or topology provide little opportunity for expansion of agricultural yields in the absence of a sustained subsidies.

Given these constraints it is no surprise that increased attention has been given in recent years in development-oriented entities such as the World Bank to the potential for expansion of the non-farm sector in rural areas as a source of income growth and poverty reduction. But this focus raises an obvious question that has long been of concern to development economists such as D. Gale Johnson: whether expansion of the non-farm sector in rural areas is predicated on the prior expansion of agricultural productivity in those areas. Absence of data on sectoral time allocations and income generation that has sufficient geographical and temporal scope has made it difficult to bring empirical insight to bear on this issue and thus the question has remained largely unresolved. There is, of course, strong theoretical grounding for the proposition that, given sufficiently low barriers to trade, there are important efficiency gains to be realized from having different regions specialize in the production of different commodities. What has been unclear is whether these barriers are sufficiently low in the context of contemporary rural areas of developing countries to achieve such gains.

In this paper we have used a thirty year panel of households from a national sample of rural India to examine this question. Our results are striking and, to our minds, unequivocal.

Growth in income from the non-farm sector in rural India over the last 30 years has been substantial and the primary source of this growth, the expansion of rural industry, is not predicated on expansion of local agricultural productivity. Indeed, as would be anticipated by a model in which rural industry producing tradable goods seeks out low wage areas, factory growth was largest in those areas that did not benefit from enhancement of local agricultural productivity growth over the study period.

Not only do these results indicate that non-farm growth can play an important role in the overall expansion of incomes in rural areas but they also suggest that non-farm growth is especially pro-poor. Poor rural households are endowed with little other than low-skilled labor and rural industry appears to be able to productively employ this labor. Thus in contrast to agricultural productivity growth, which expands the return to a factor that is concentrated among the better-off households (land) in addition to expanding the return to unskilled labor, entry of the factory sector tends to have a greater proportional impact on the income of the poorest members of the village. This is not to say that investment in agricultural productivity growth is not an important dimension of an overall strategy for poverty reduction in rural areas of low-income countries. Instead, it suggests that, from the perspective of poverty reduction, removal of barriers to non-farm capital and product mobility within and across countries is an important complement to investments in agricultural productivity that target those areas well suited to cultivation.

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Table 1
Estimates of the Determinants of Total Agricultural Income: 1971-99

Variable	GLS	FE	FE
Log of HYY yield index	.281 (4.60) ^a	.210 (3.52)	.209 (3.44)
Total crop-year rainfall (mm x 10 ⁻³)	-.0662 (1.22)	.255 (2.64)	.249 (2.51)
Rainfall in March (mm x 10 ⁻³)	-.1.71 (1.79)	-2.70 (2.62)	-2.67 (2.59)
Distance to mandi < 5km	.136 (2.00)	.266 (2.67)	.265 (2.79)
Year=1982	-.452 (6.59)	-.314 (3.45)	-.280 (2.70)
Year=1999	-.536 (3.64)	-.402 (2.96)	-.370 (2.39)
Distance to town in 1971*year=1982 (km x 10 ⁻³)	-	-	-.0679 (0.44)
Distance to town in 1971*year=1999 (km x 10 ⁻³)	-	-	-.0247 (0.13)
Bank in village	-	-	-.0200 (0.21)
Post office in village	-	-	-.0777 (0.76)
Constant	6.90 (18.8)	-	-
Number of observations	705	705	705

^aHuber/White estimates of absolute values of t-ratios in parentheses.

Table 2
 Estimates of the Determinants of Village Factory Presence, Log of Mean Non-farm Wage Income, and Log of Mean Business
 Income: 1971-99

Dependent Variable	Factory in Village		Log of Non-Farm Wage Income		Log of Business Income	
	GLS	FE	GLS	FE	GLS	FE
Log of HYY yield index	-.00543 (0.29)	-.0719 (2.87)	.127 (1.07)	-.246 (2.14)	.270 (2.02)	.105 (0.75)
Year=1982	.0558 (1.56)	.114 (2.81)	-.0086 (0.04)	.522 (2.22)	1.02 (4.80)	1.17 (4.81)
Year=1999	.0755 (2.00)	.178 (3.48)	2.01 (8.23)	2.81 (10.9)	-.367 (1.15)	-.0844 (0.26)
Distance to town in 1971*year=1982 (km x 10 ⁻³)	.0905 (1.49)	.0530 (0.69)	1.27 (3.82)	.326 (0.88)	.208 (0.81)	.150 (0.33)
Distance to town in 1971*year=1999 (km x 10 ⁻³)	.179 (2.71)	.141 (1.77)	.468 (2.26)	-.495 (1.43)	.617 (1.48)	.534 (1.05)
Constant	.141 (1.35)	-	4.29 (6.42)	-	2.68 (3.54)	-
Number of observations	705	705	705	705		705

^aHuber/White estimates of absolute values of t-ratios in parentheses.

Table 3
Estimates of the Determinants of Log of Total Income: 1971-99

Variable/Estimation procedure	GLS	FE
Log of HYY yield index	.149 (5.64)	.0523 (1.81)
Year=1982	-.147 (3.47)	-.082 (1.42)
Year=1999	.179 (2.11)	.300 (3.18)
Distance to town in 1971*year=1982 (km x 10 ⁻³)	.0290 (0.42)	.0632 (0.70)
Distance to town in 1971*year=1999 (km x 10 ⁻³)	.0580 (0.57)	.0993 (0.94)
Constant	7.80 (54.3)	-
Number of observations	705	705

^aHuber/White estimates of absolute values of t-ratios in parentheses.

Figure 1: Average Maximum HYV Yield Index (Laspeyres-weighted HYV Crops), by Year: 1971-1999

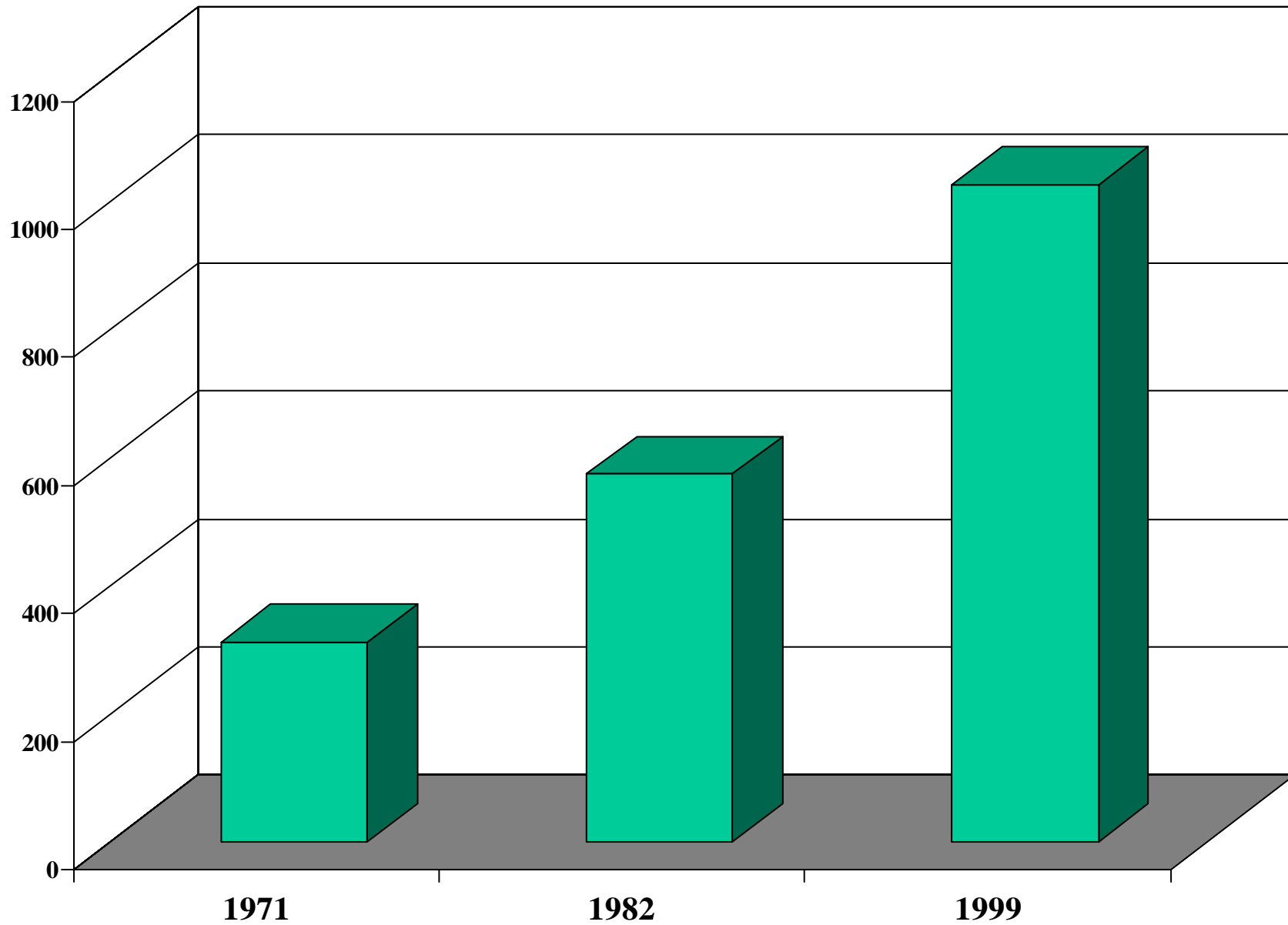


Figure 2: Distribution of Absolute Growth of HYV Yields, 1971-99

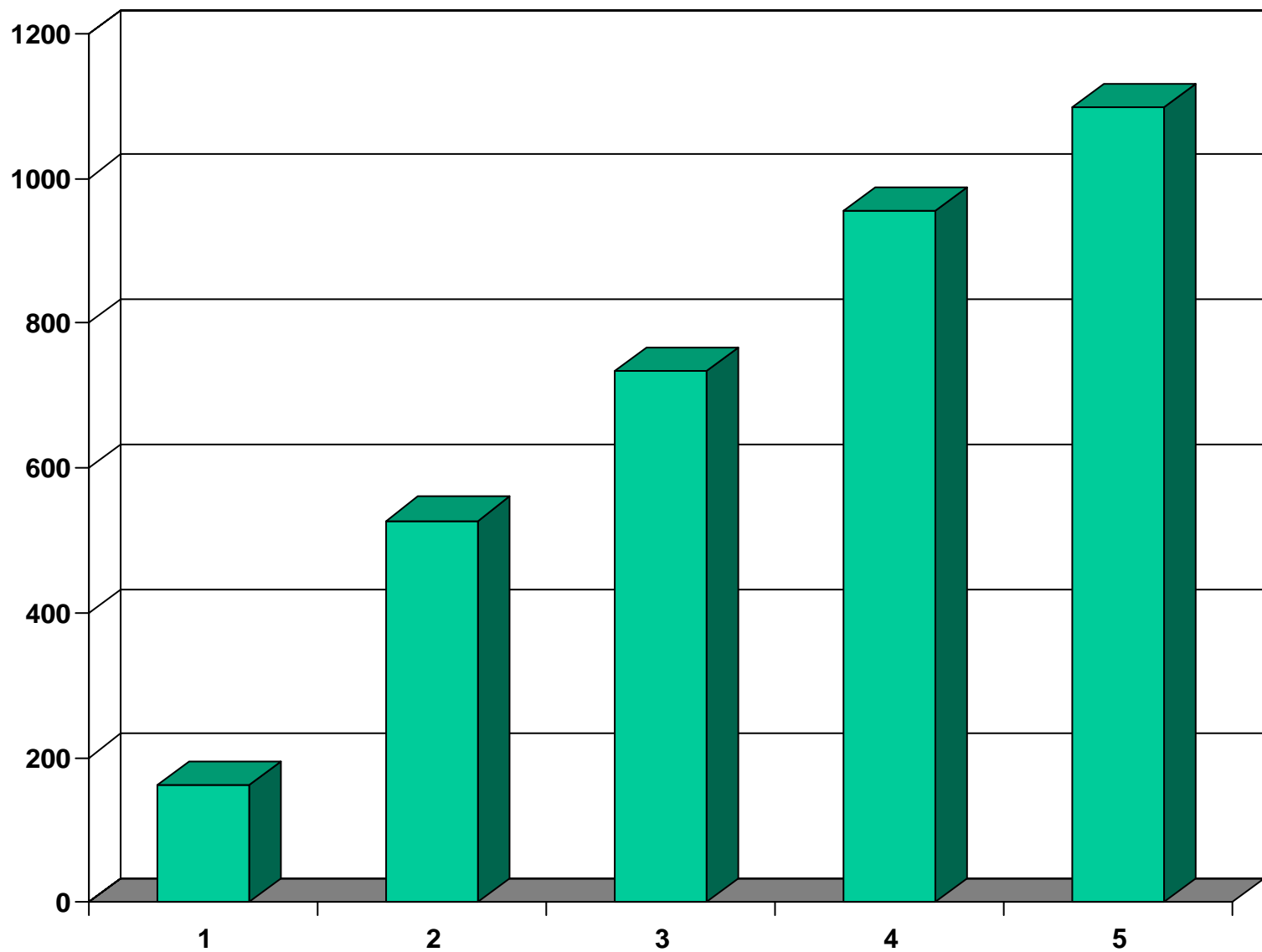


Figure 3: Land Wealth by Year and HYV Yield Growth, 1971-99

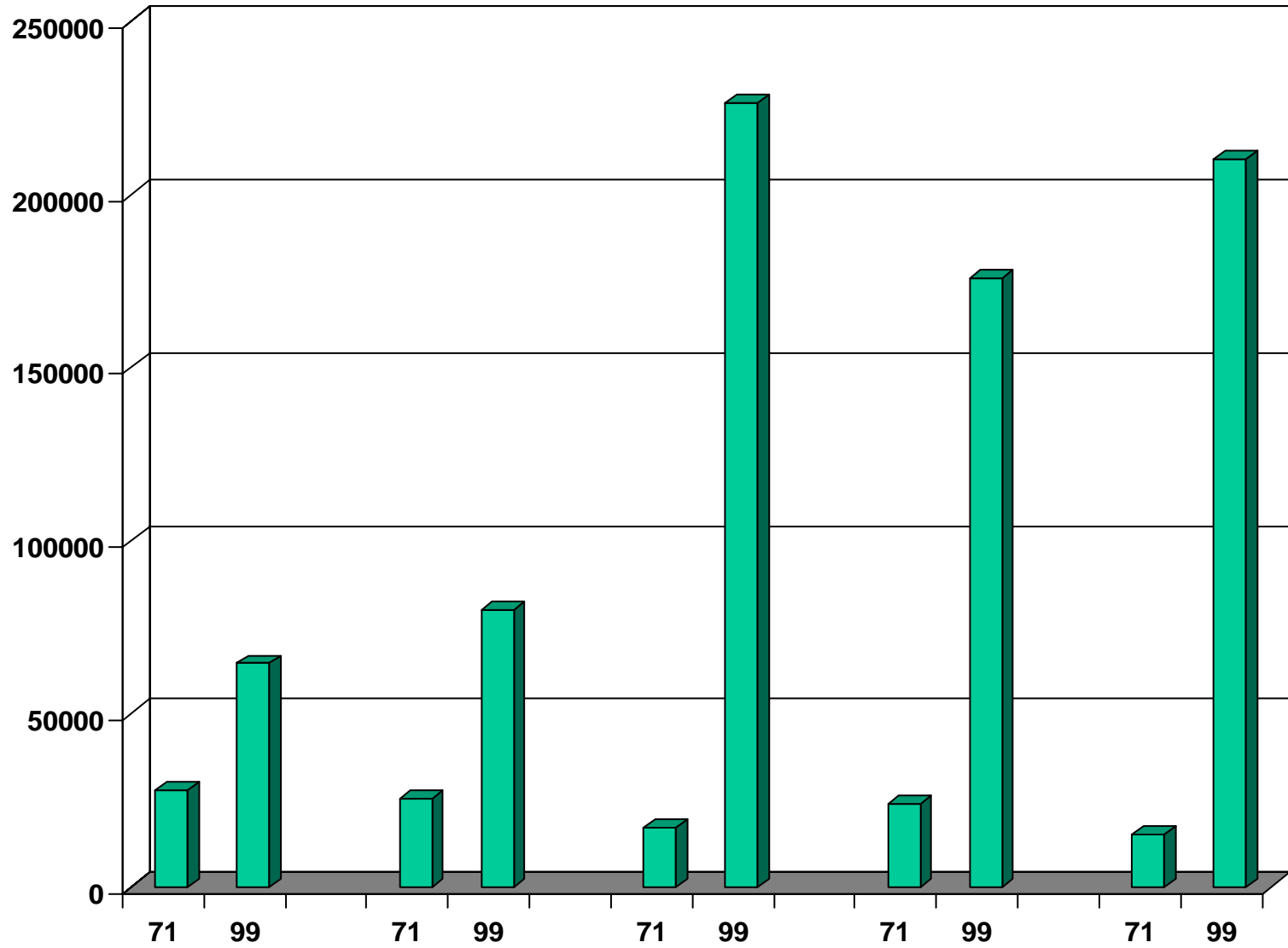


Figure 4: Land Prices, by Year and HYV Yield Growth, 1971-99

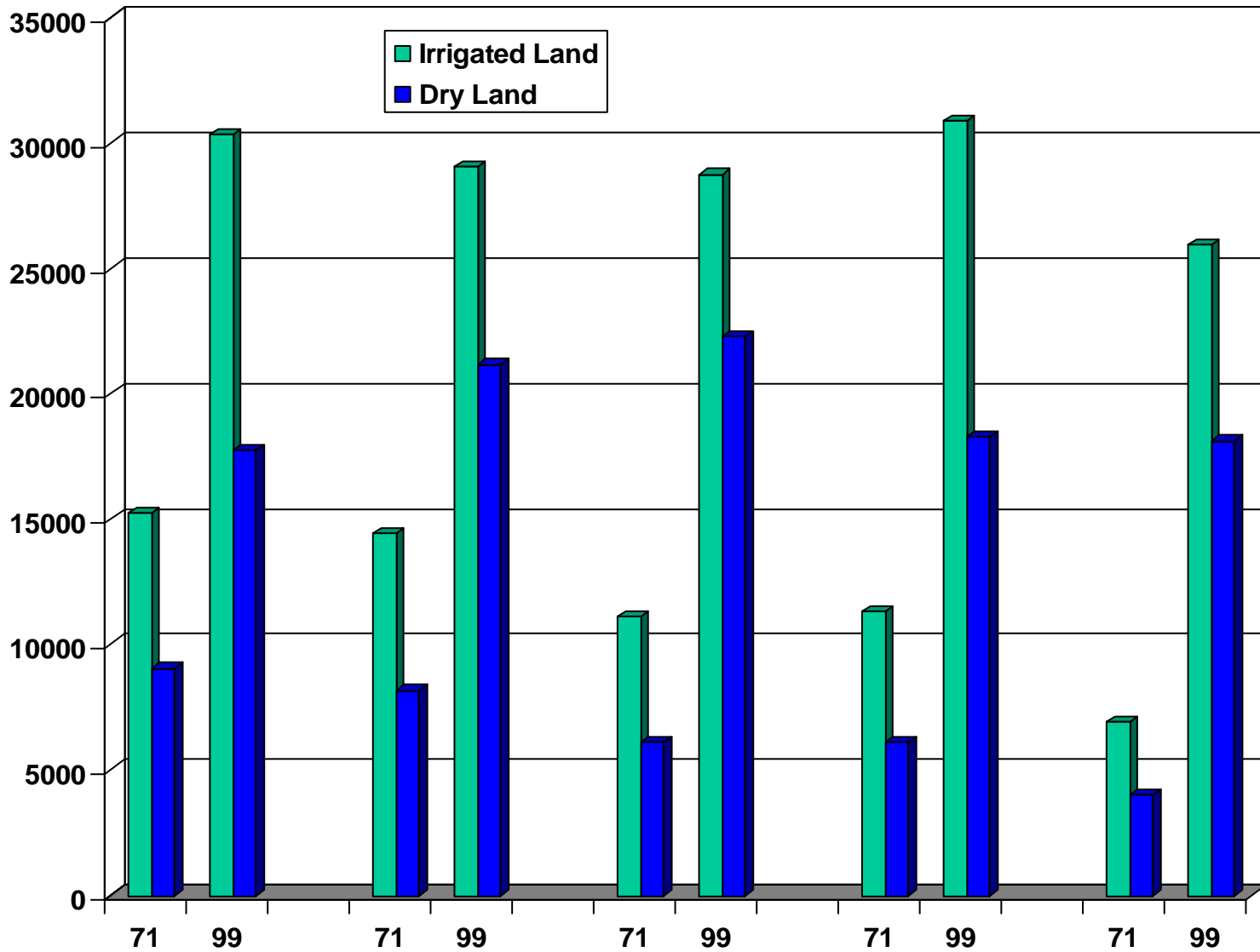


Figure 5: Share of Irrigated Land, by Year and HYV Yield Growth

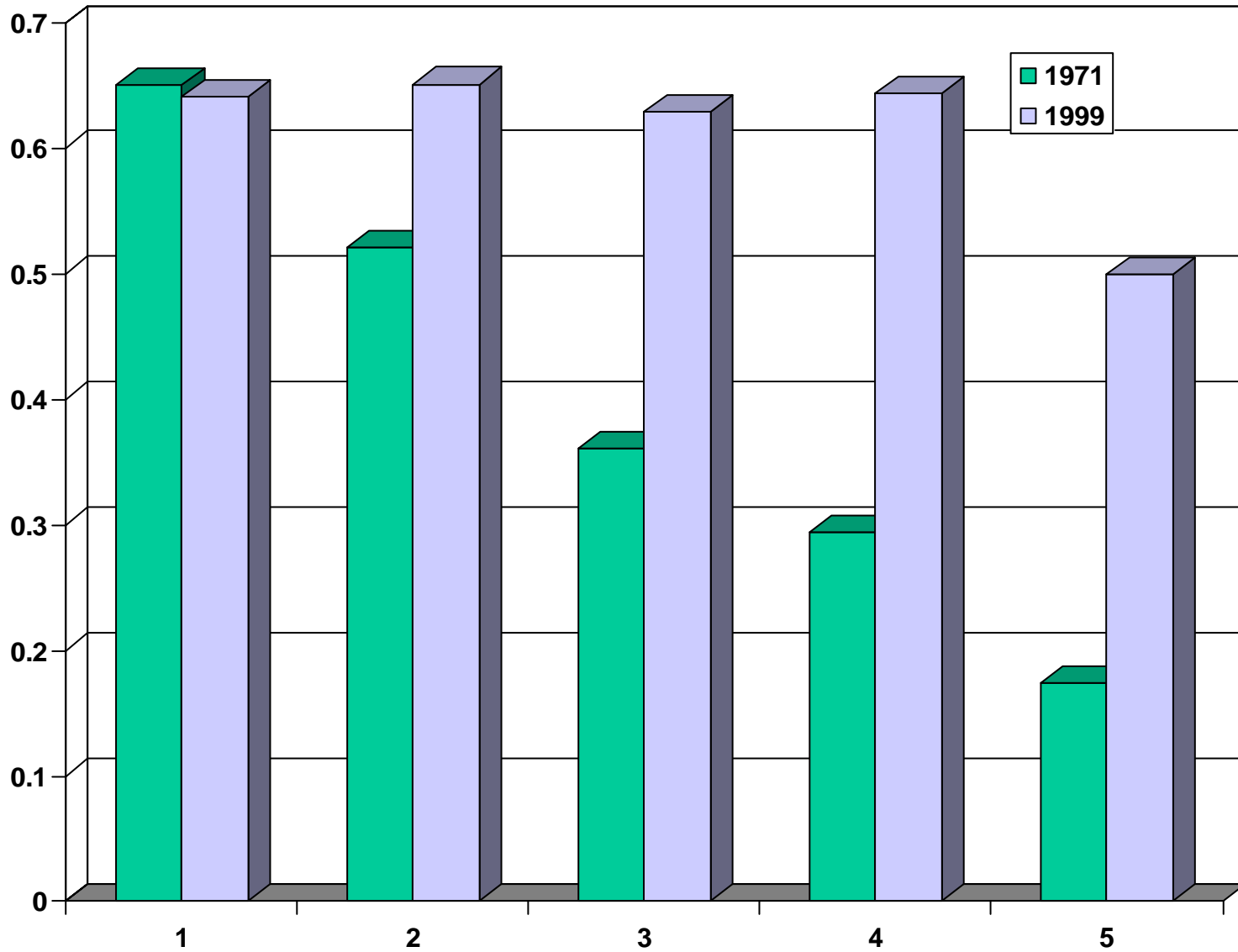


Figure 6: Mean Real Per-Capita Household Income (1982 Rupees), by Source and Year, 1971-99

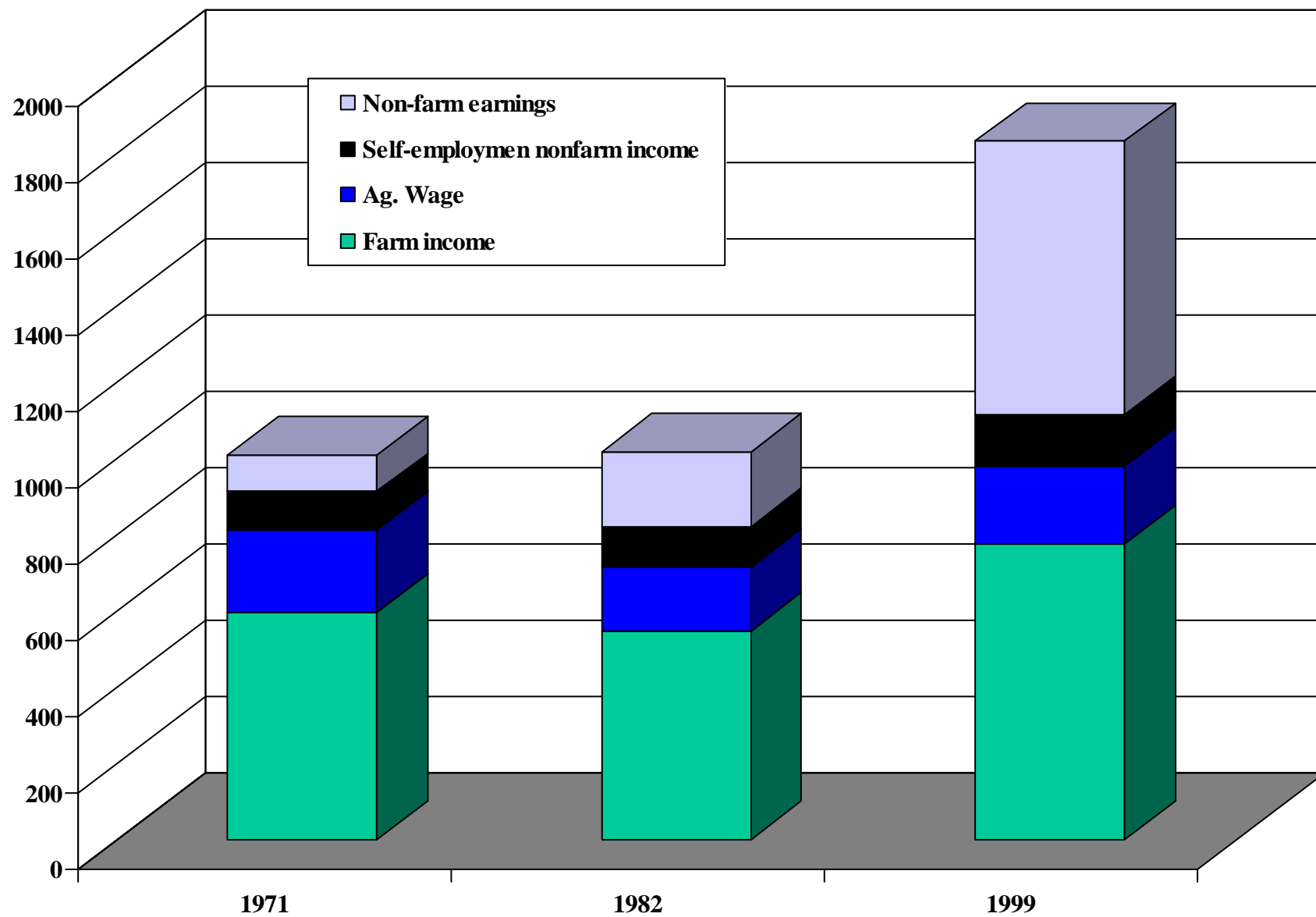


Figure 7: Distribution of Primary Activities of Men Aged 25-44, by Year, 1971-99

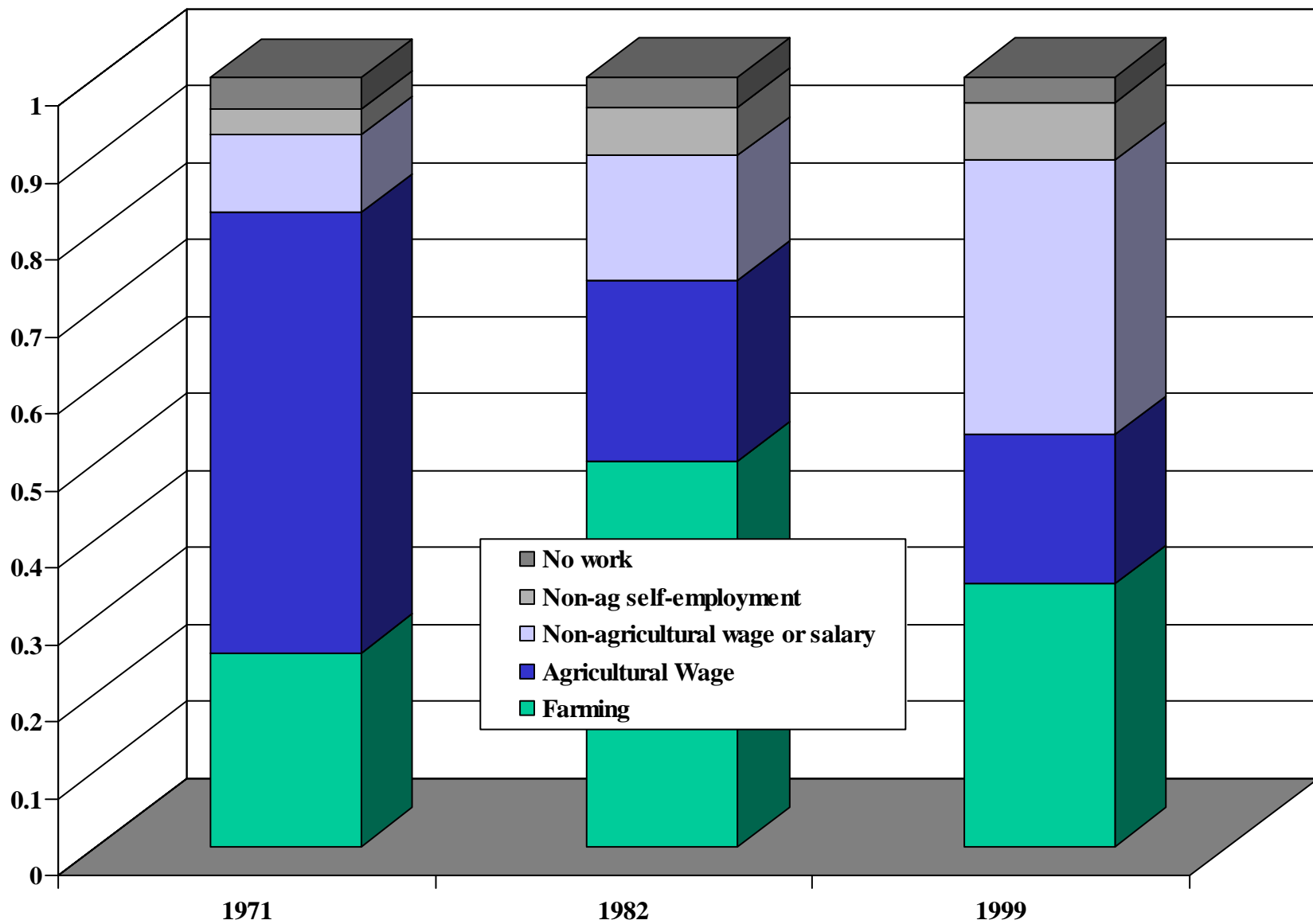


Figure 8: Mean Real Non-land Household Assets, by Type and Year, 1971-99

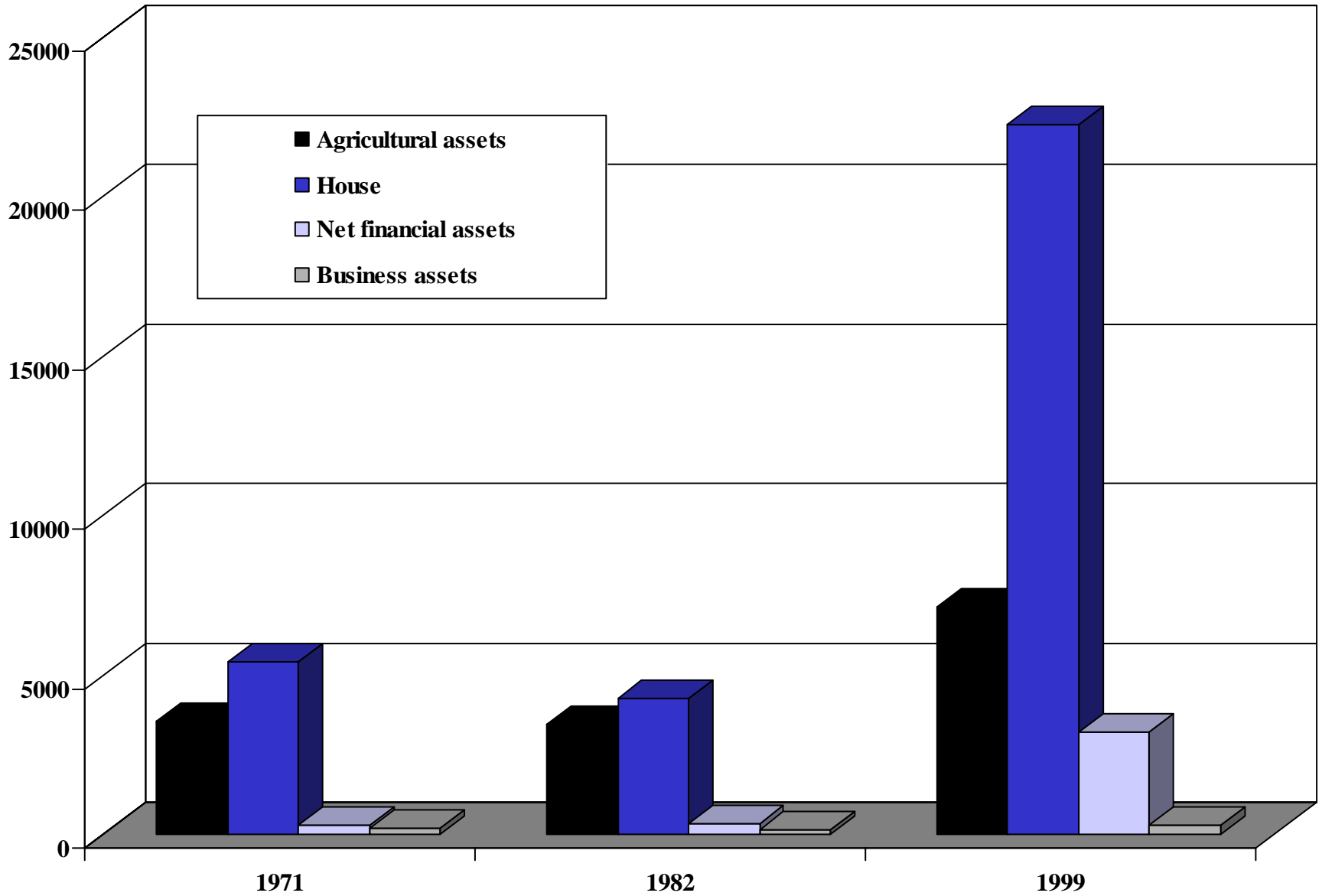


Figure 9: Proportion of Villages with Proximate Financial Institutions, by Type and Year

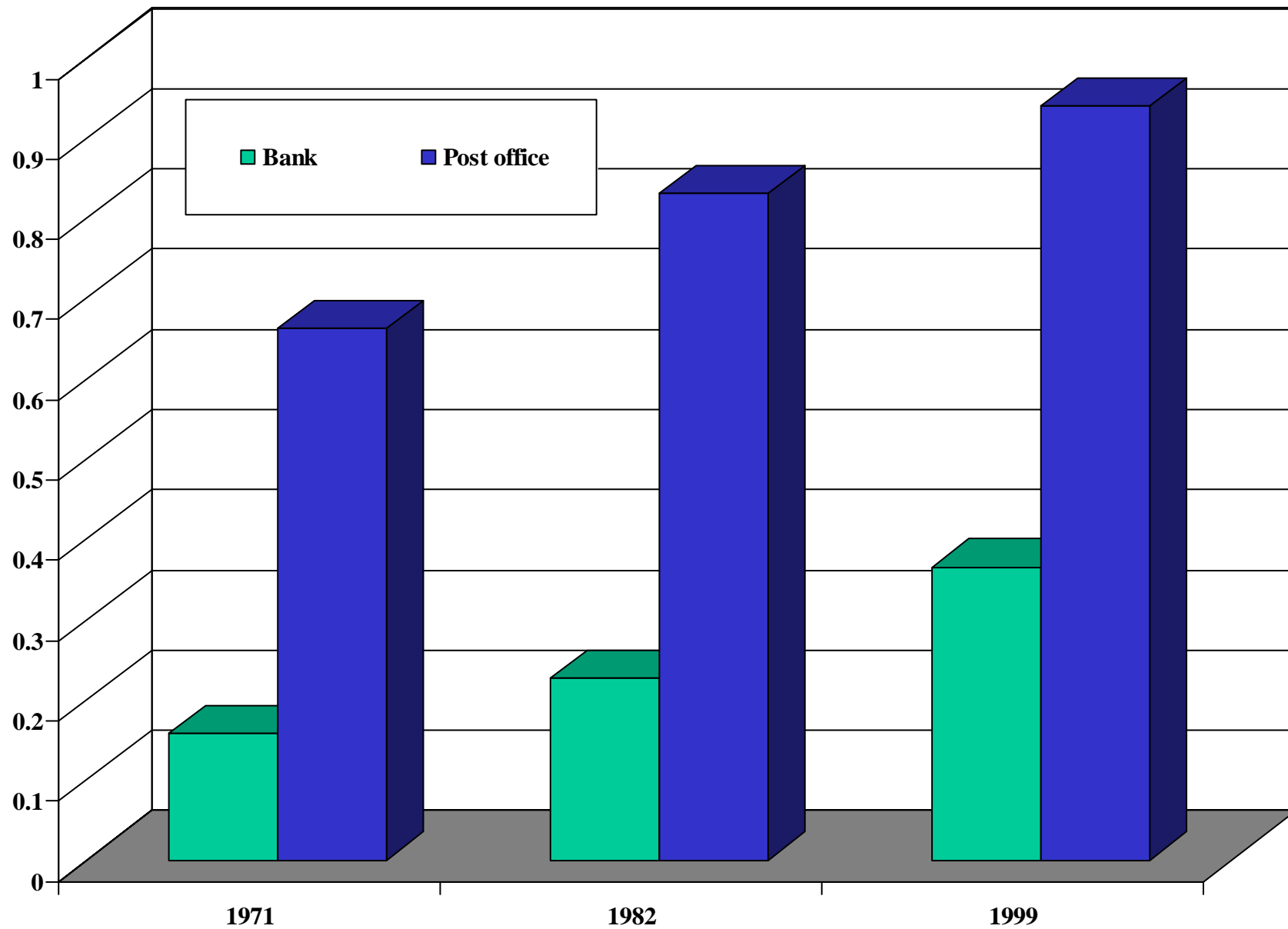


Figure 10: Proportion of Villages Proximate to Towns by Year, 1971-99

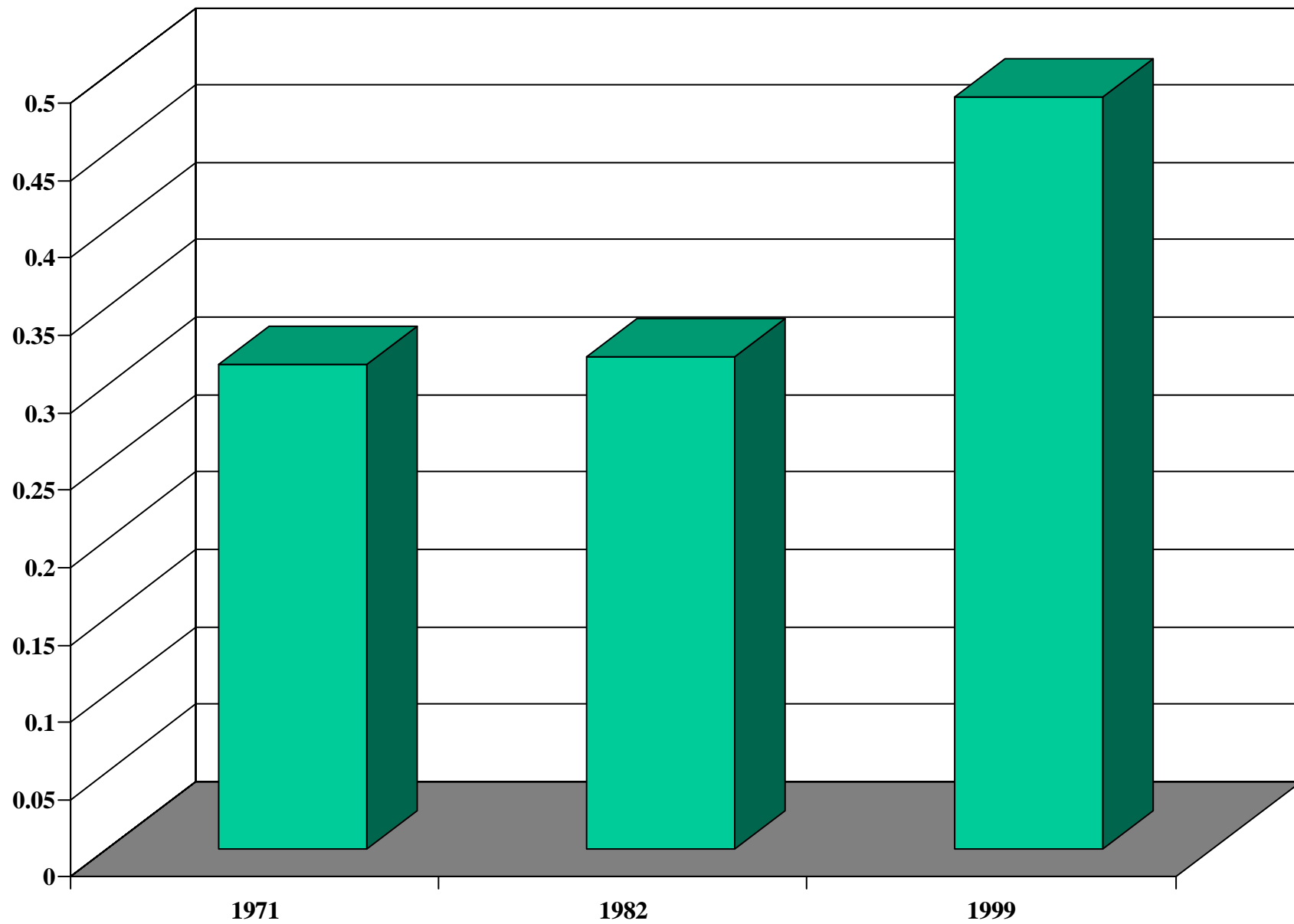
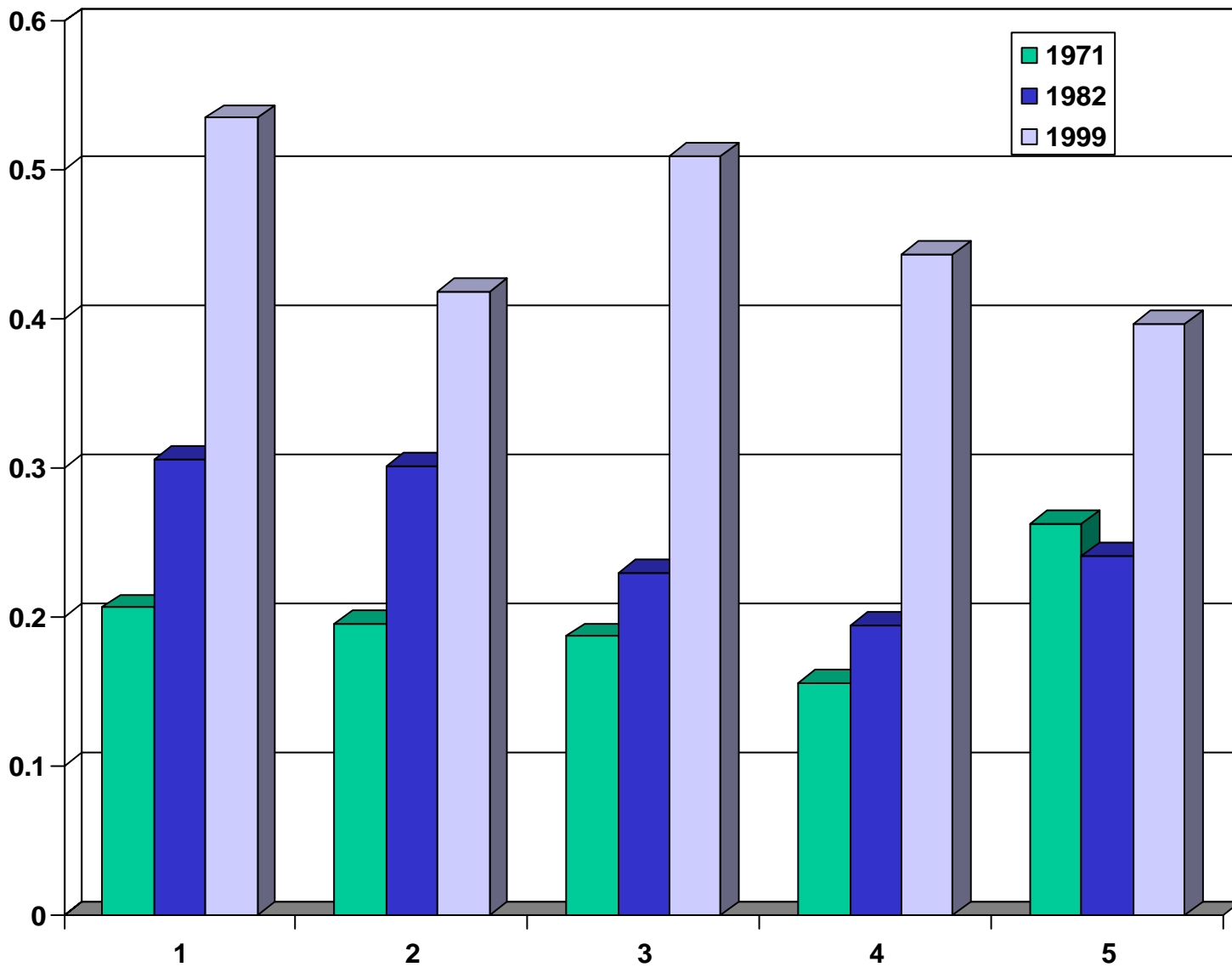


Figure 11: Proportion of Nonfarm Income in Total Income, by Year and HYV Yield Growth



**Figure 12: Proportion of Non-Land Assets that are Business Assets,
by Year and HYV Yield Growth, 1971-99**

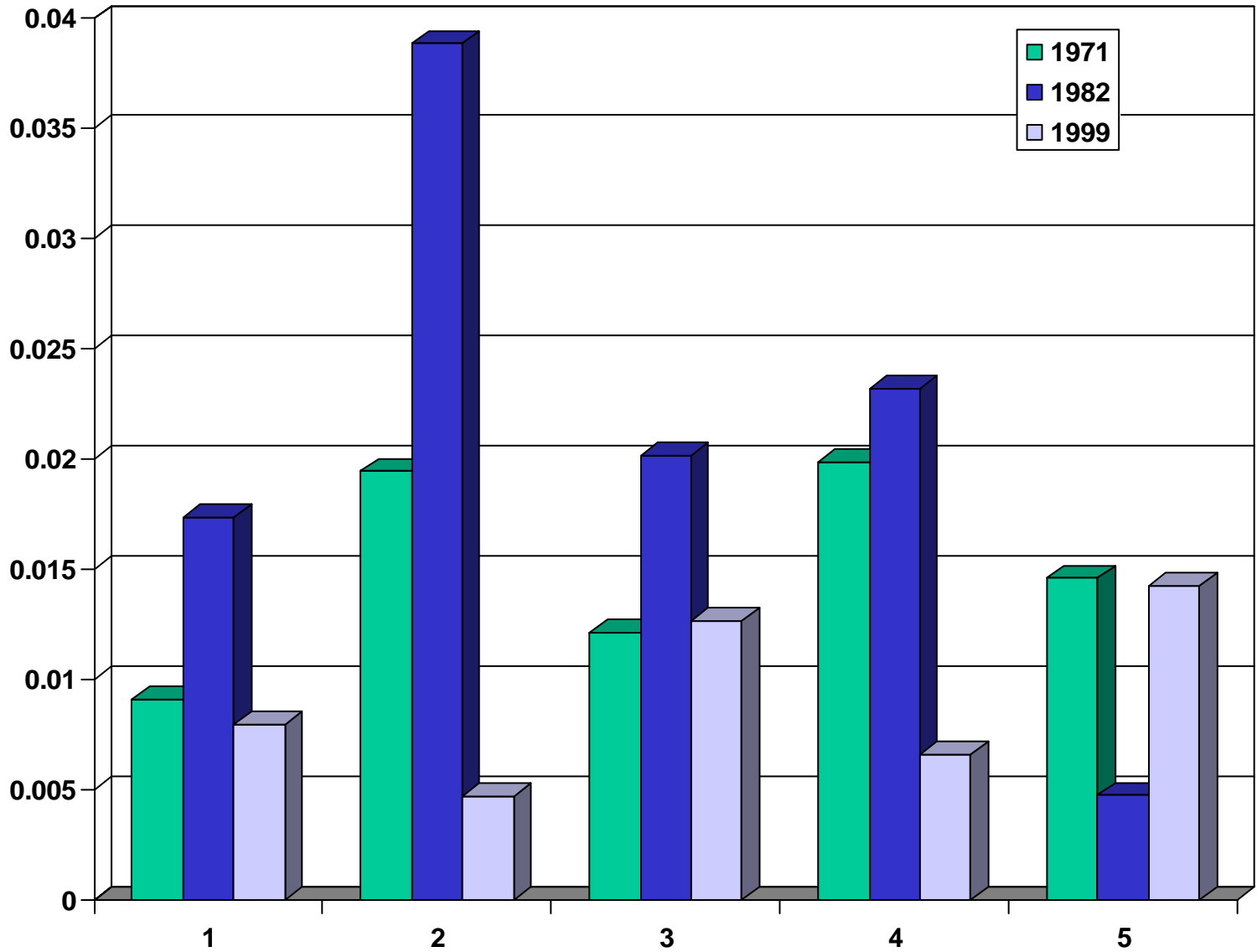


Figure 13: Real Non-farm Wage and Salary Income and Business Income, by HYV Yield Growth in 1971

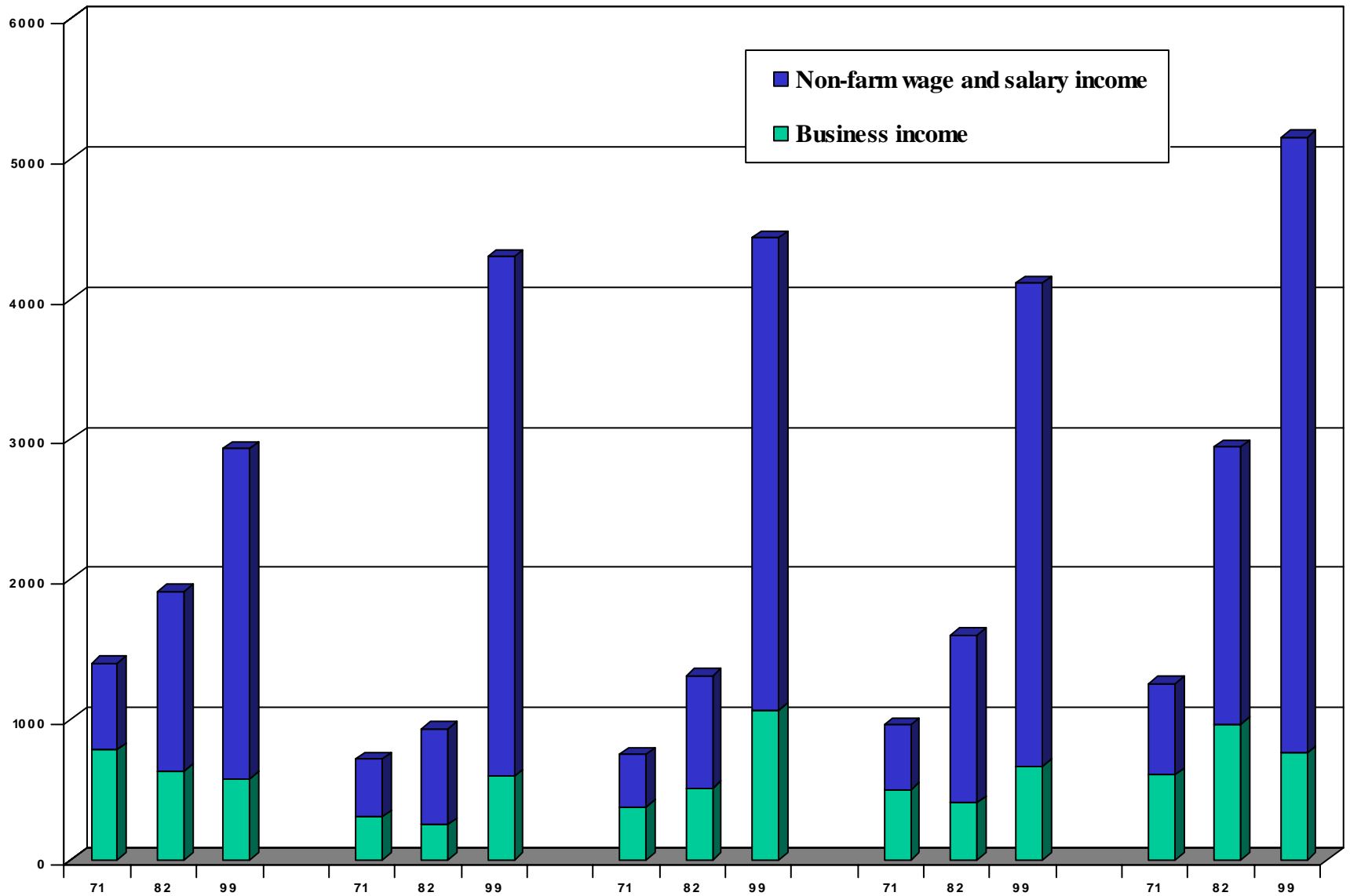


Figure 14: Proportion of Men Aged 25-44 by Primary Activity, Year and HYV Yield Growth

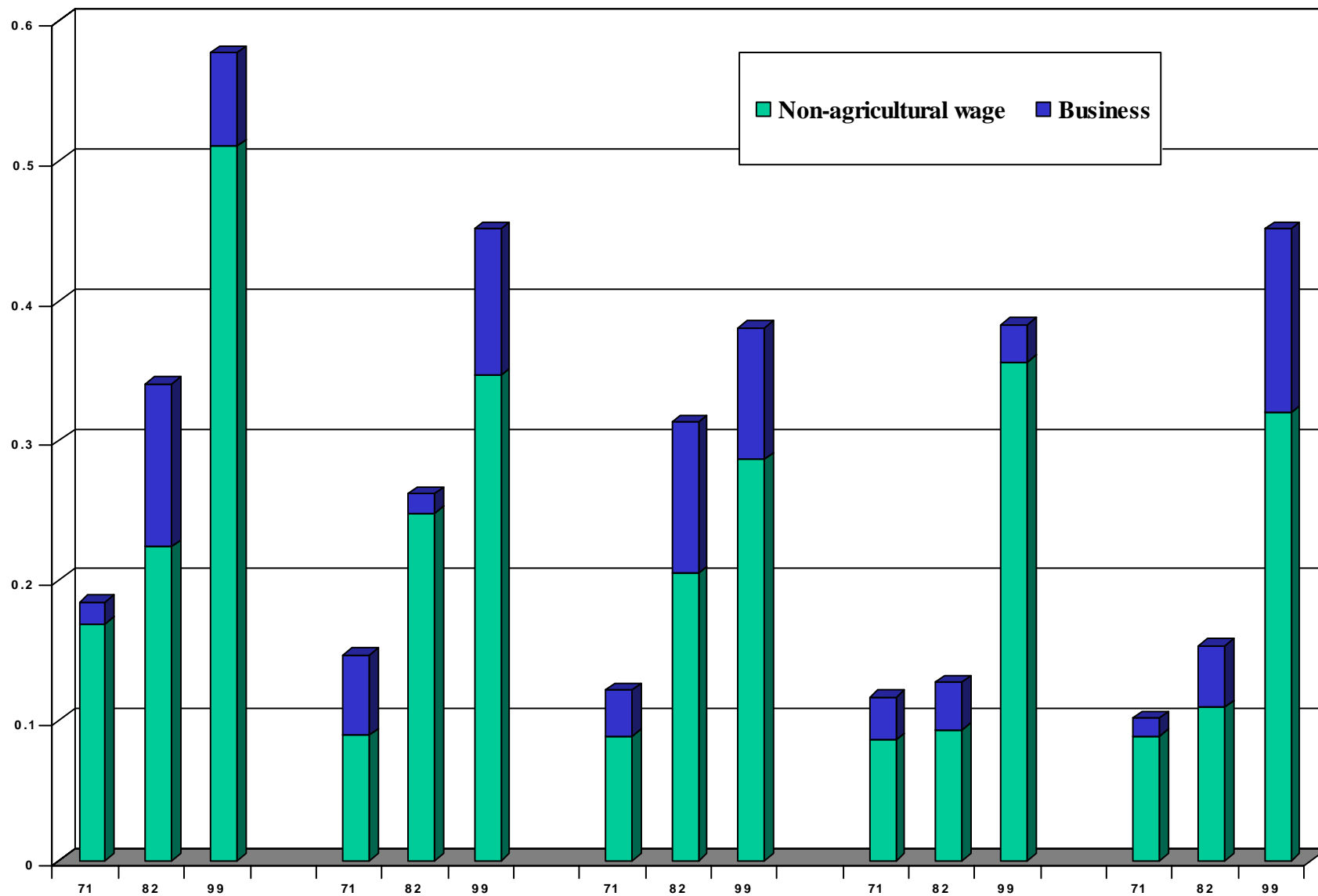


Figure 15: Proportion of Villages with at Least One Factory, by Year and HYV Yield Growth

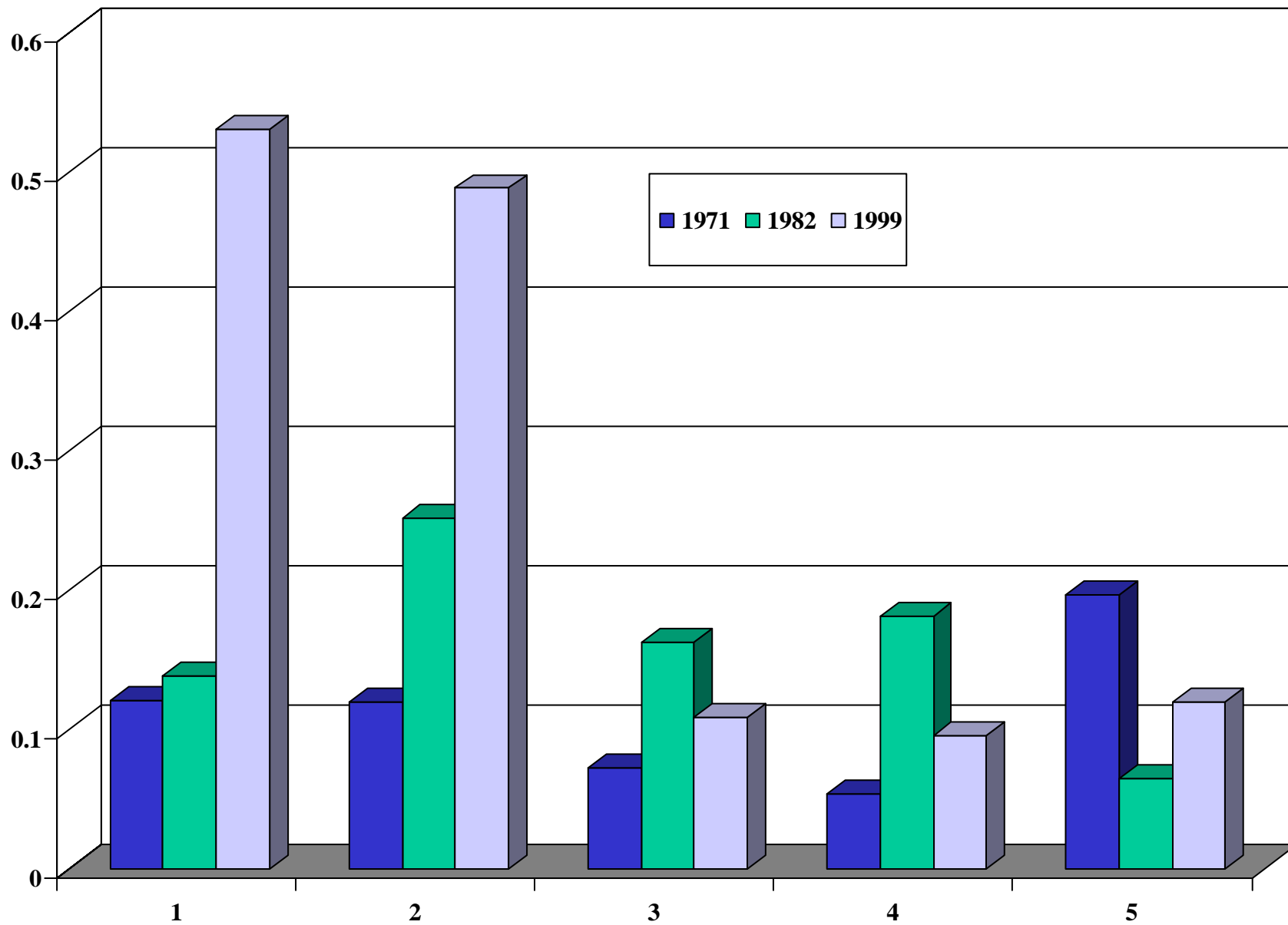


Figure 16: Number of Factory Workers per Village in 1982 and 1999 by HYV Yield Growth, 1971-99

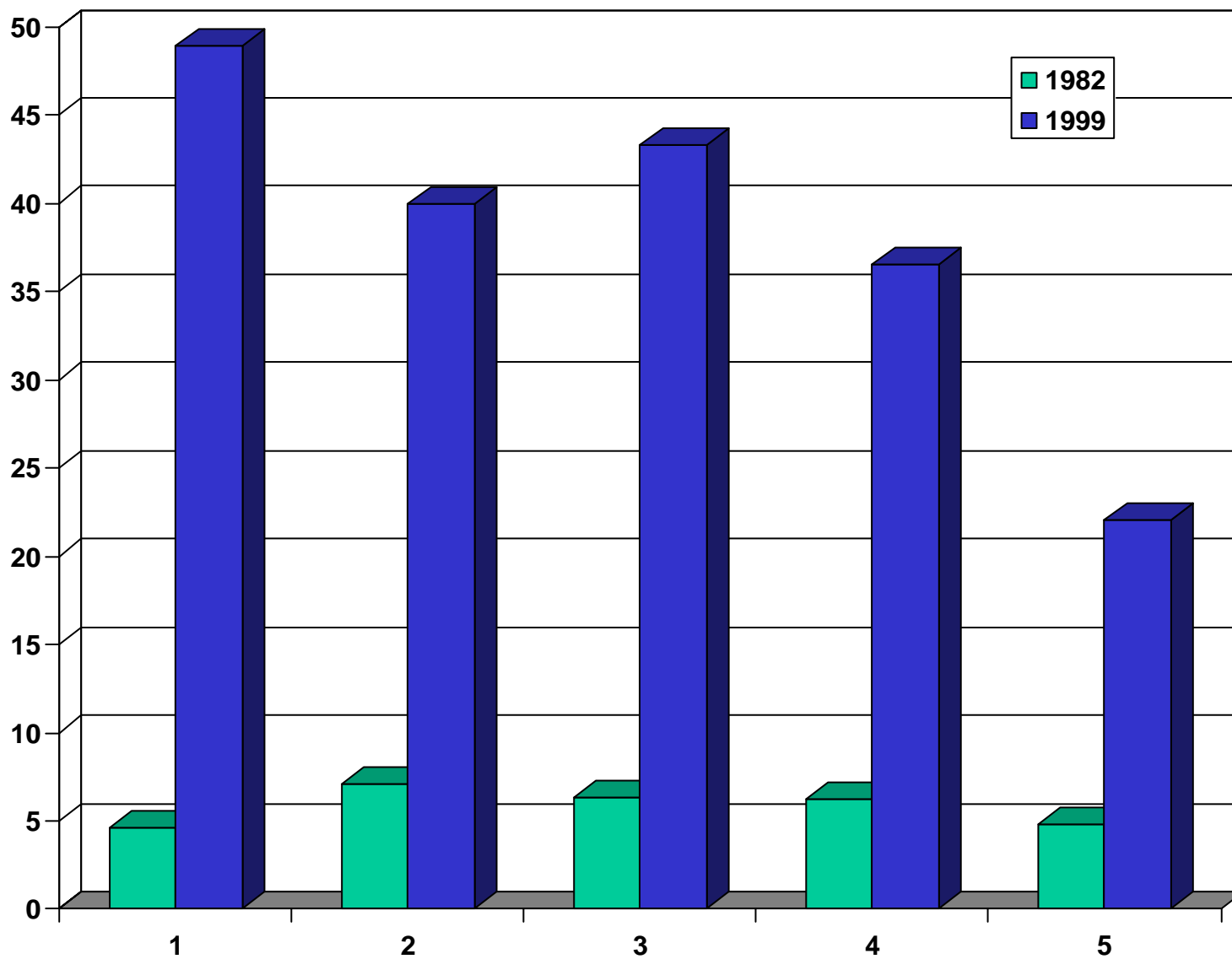


Figure 17: Number of Local Service Enterprises, by Year and HYV Growth

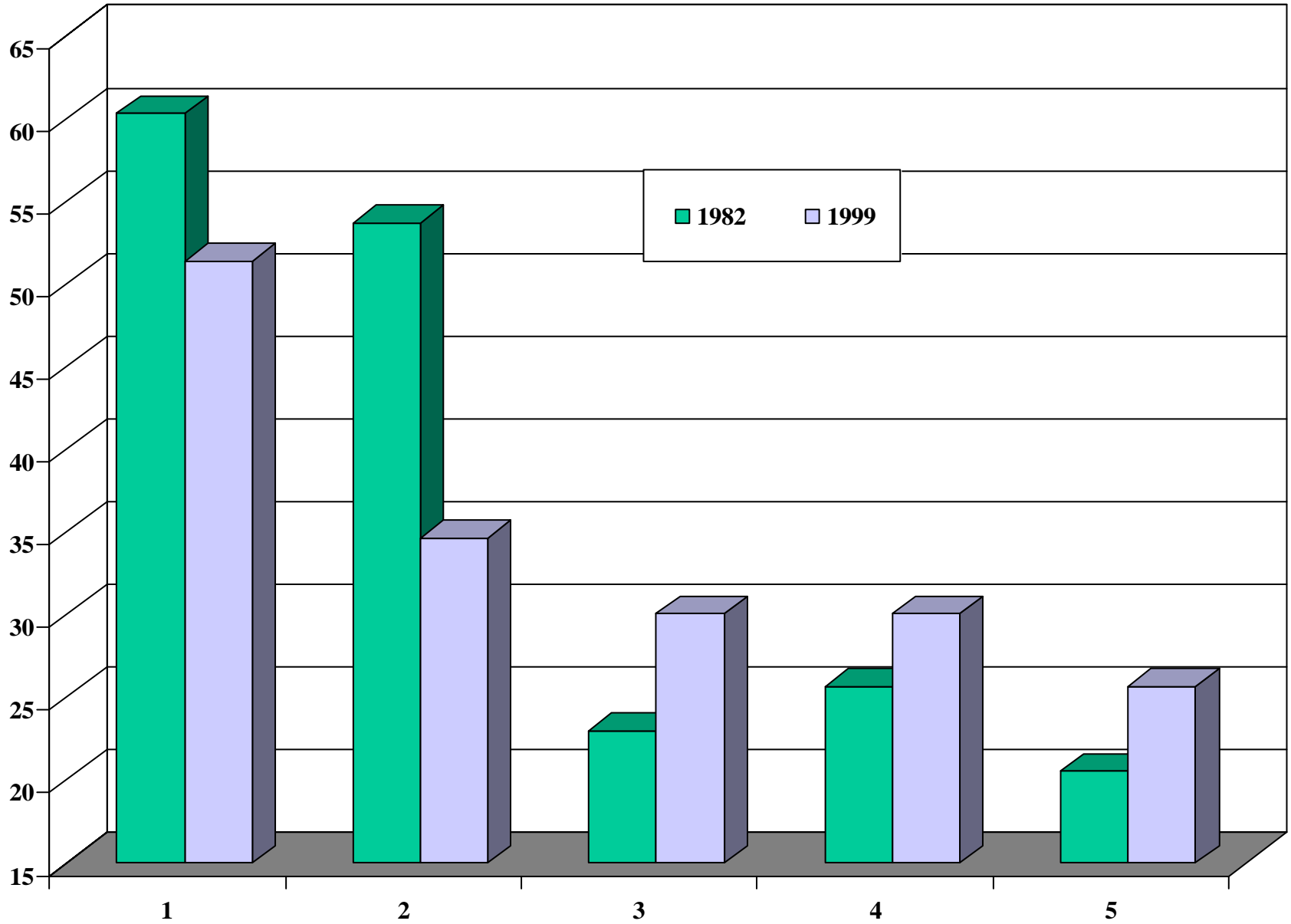


Figure 18: Wealth, by Type, Year and HYV Yield Growth

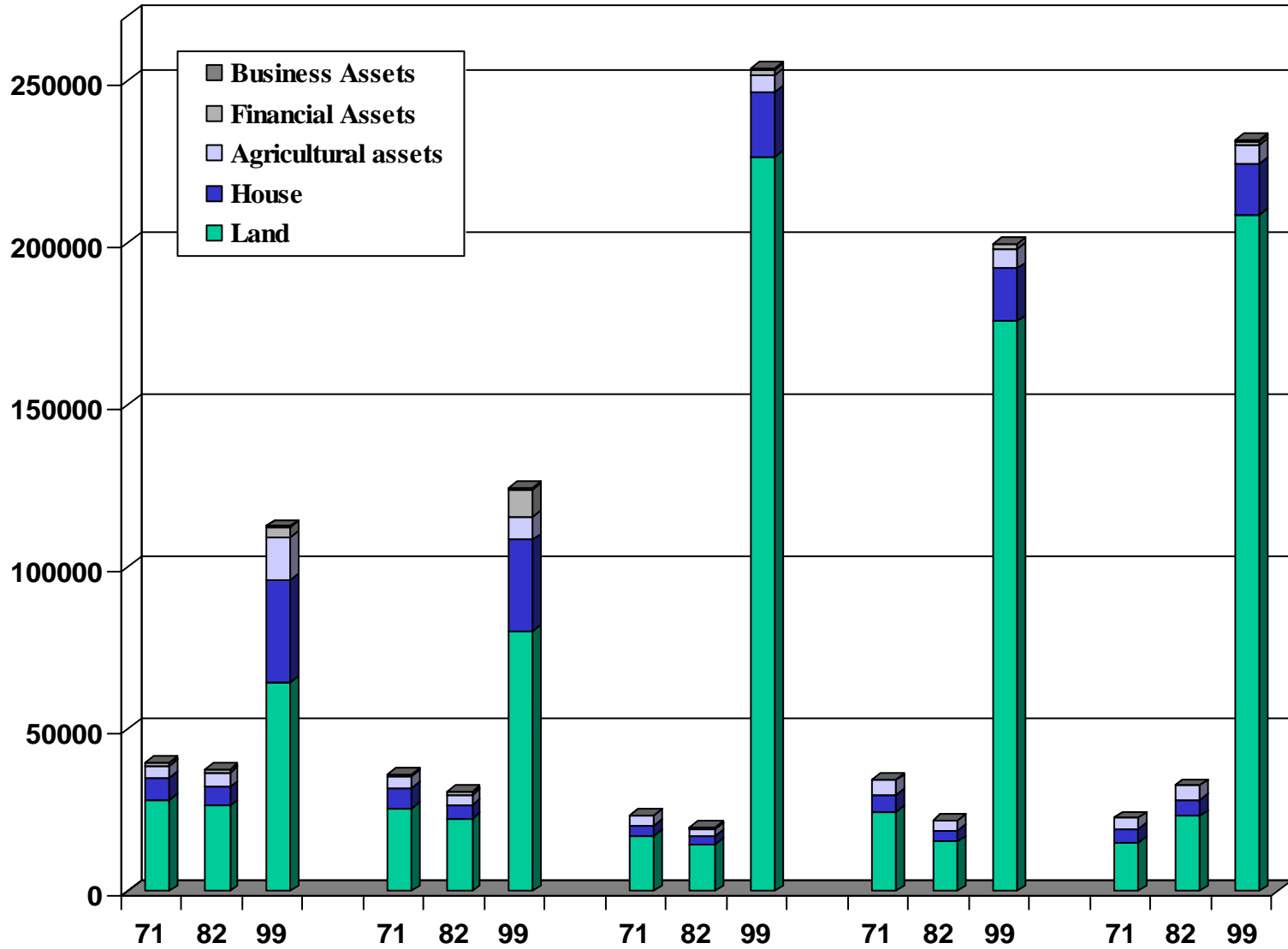


Figure 19: Assets by Type and Year and HYV Yield Growth, 1971-1999

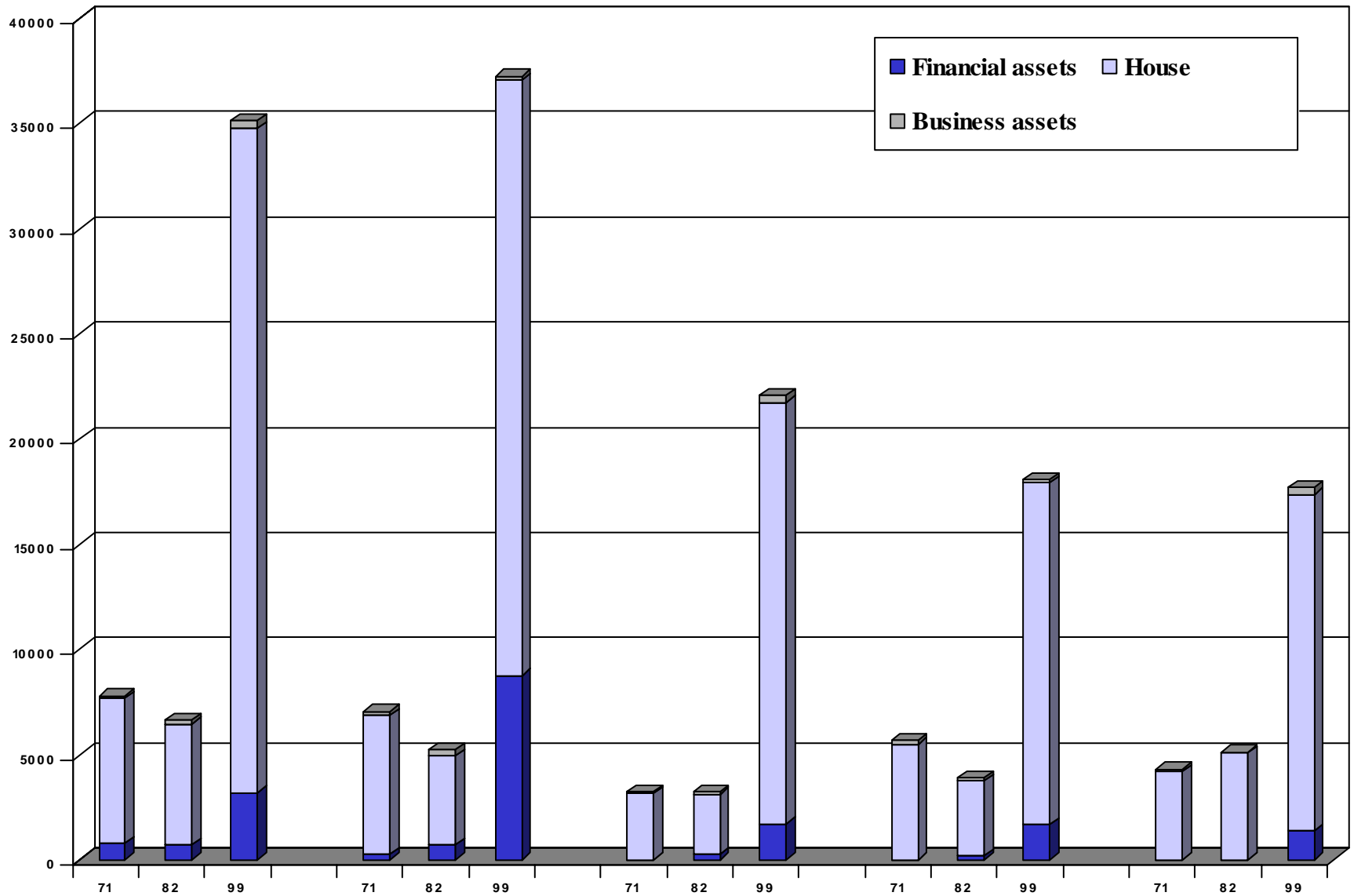


Figure 20: Proportion of Nonfarm Income in Total Income, by Year and Proximity to Town

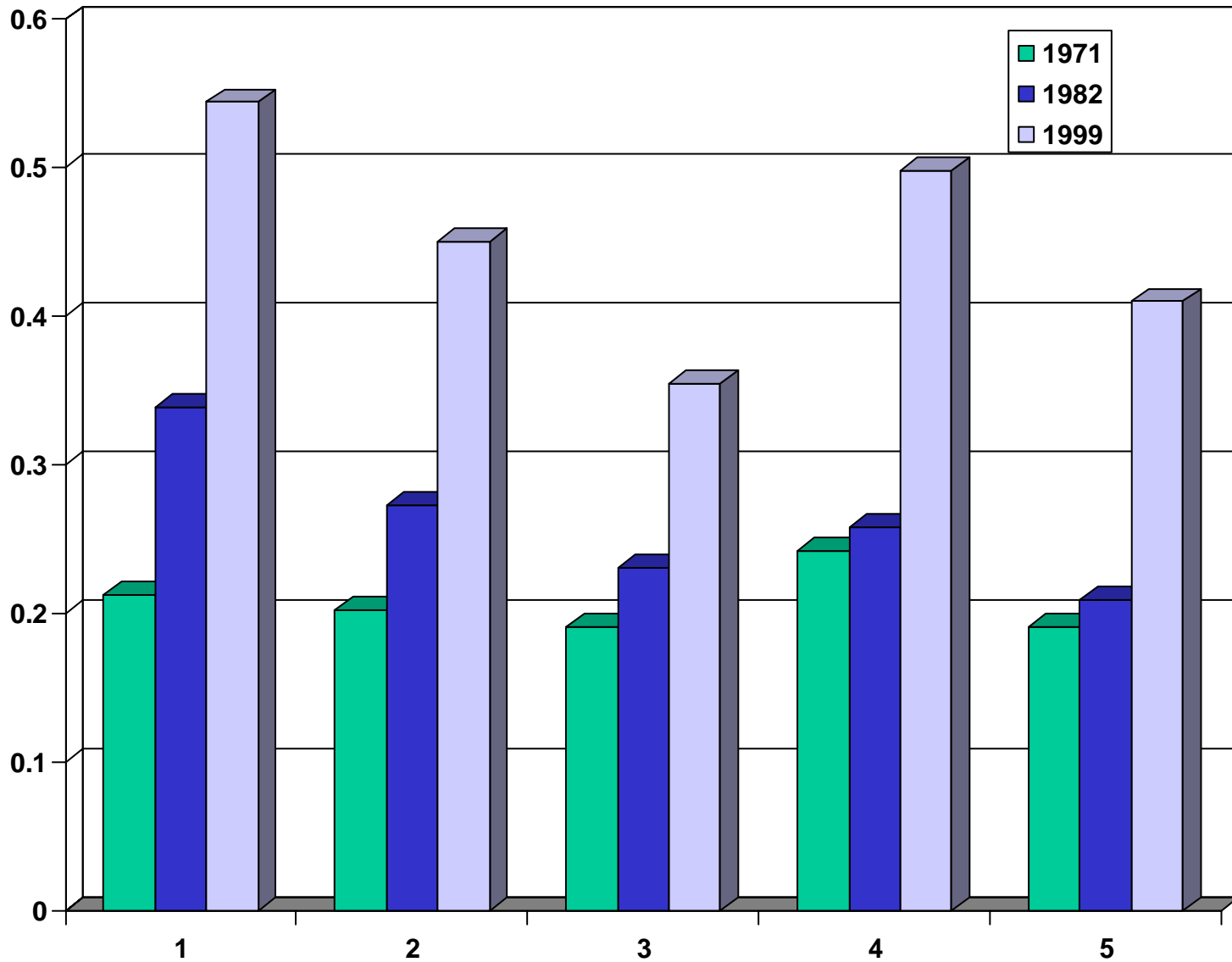


Figure 21: Proportion of Nonfarm Employee Income in Total Nonfarm Income, by Year and Proximity to Town

