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# Economic Efficiency of Agricultural Research

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**Abstract:** The economic dimension of science has been one of the most treated problems in economics during the past three and a half decades. Over 6,000 publications appeared on the assessment of research results; several hundred formulae have been proposed to measure the efficiency of research workers, research institutions, and of science as a whole. The different aspects of research activity and its role in the realization of social goals have also been clarified. However, the overall economic theory of research efficiency is still in its formative stage. The number of studies of agricultural efficiency increased in parallel with agriculture's share in the economy, the growth of society, and with the amount of resources allocated to development of agricultural production. During the past decade, considerable progress has been made in clarifying the approach to estimation of research efficiency in agriculture, using agricultural economic analytical techniques, and identifying factors affecting efficiency growth in research and innovation. This paper presents some ideas related to scientific efficiency in agricultural research. It also estimates the economic efficiency of wheat selection in Bulgaria.

## Introduction

The problem of the economic dimensions of science has been given considerable attention in the economic literature during the past 35 years (Braunstein, 1980; Dobrov, 1978; Mansfield, 1968; and Twiss, 1986). During this period, over 6,000 publications appeared on the assessment of research results, several hundred formulae were proposed to measure the efficiency of research workers, research institutions, and of science as a whole (Zavlin, 1980). Various aspects of research activity and its role in the realization of social goals have been clarified. However, the economic theory of research efficiency is still at a formative stage.

The number of studies of agricultural efficiency increased, as did agriculture's share in economic growth and the resources allocated to development of agricultural production (Griliches, 1963; Latimer, 1965; and Matthews, 1964).

During recent decades, there has been considerable progress in clarifying the approach to estimation of research project efficiency in agriculture, using agricultural analytical techniques (Arnon, 1968; Griliches, 1958; Capablo, 1988; and Metcalf, 1970) and of the factors affecting studies of the growth of efficiency and the innovation process (Jones, 1963; and Metcalf, 1970).

The economic effects of the application of research achievements can be seen in the following three forms: in national income growth (additive value), in the size of averted losses, and in the increase of nonproductive (free) time. Often it occurs on a scale that exceeds the limits of economically differentiated groups of the economy. This requires that economic analysis of research take account not of its local effect in these separate groups within the scientific cycle but of its importance for the national economy.

This paper discusses techniques of evaluating and estimating agricultural research efficiency, with particular reference to determining the economic efficiency of wheat selection in Bulgaria.

## An Estimation of Research Efficiency of Wheat Selection in Bulgaria

Until the mid-1980s, wheat production in Bulgaria was based mainly on varieties selected abroad. During 1976–89, 35 new varieties of wheat were created, established, and distributed in Bulgaria. They had to meet various economic criteria, and their application determined the scientific and technical level of production during the period.

The economic effects of introducing new varieties are estimated using (1) the results of annual, agro-ecological testing under the state system of variety testing (in 30 experiment stations) and (2) statistical information on the extent of introduction by main agro-ecological regions.

The optimum results in the corresponding agro-ecological regions are used to test the new varieties. Compared to the control (base), the test regions do not feel the economic effects of changes in production costs per unit, since new varieties are grown under similar technological conditions. Representative samples of the respective types and groups of wheat are used for comparison of grain quality. The complete comparability of all factors allows the annual economic potential created by selection to be differentiated. Under these conditions, the economic potential finds expression in the rate (or change) of incomes per unit of area as a result of increased productivity and quality of the new varieties compared to the basic ones.

The introduction of Bulgarian selected varieties has resulted in changes in the variety structure of wheat production. Compared with 16 percent in 1975, Bulgarian varieties of wheat have covered almost the entire country since 1983.

The speed of realization of economic potential varies between varieties from 1–2 years to 7–9 years for simple wheat, 3–4 years for strong wheat, and 2–4 years for hard wheat. The scale of introduction for the different varieties has different dynamics. A variety's share in the total volume of production also varies when its economic potential is exhausted and during the whole period of effective use. The percentage of wheat introduction in more than 10 percent of the area under wheat for the different years is 19 percent; strong and hard wheat is 100 percent. The importance of the different varieties also varies in terms of their contribution to improving the variety structure of wheat production. The share of the new varieties of soft wheat, introduced on over 1 million dka, is 50 percent. They account for 90.7 percent of the total volume of area under new varieties during the period.

Economic potential is realized on 22.5 percent of the area under new wheat varieties. This percentage gives an idea of the total quantity of land necessary to realize efficient scientific and technical progress in the field of wheat selection during the period of analysis.

The new varieties contribute to the formation of a variety structure to varying extents in the respective agro-ecological regions and subregions. Their largest share in total wheat production is found in the Danube-Dobruja and Central Northern Bulgarian regions, where they exceed national innovation levels by about 10–12 percent and 6–8 percent, respectively. The percentage and absolute scale of variety innovation is greatest in the Danube-Dobruja region, which contains over 50 percent (64 percent during 1976–80) of the total area in which new varieties were introduced. The distribution of the new varieties in the different agro-ecological regions and subregions gives an idea of the regional distribution of newly created varieties.

The total economic potential effect of introduction of new wheat varieties during 1976–89 can be valued at 52,169,913 leva (Table 1). The extent of actual realization of economic potential of the new varieties when widely introduced is 60–70 percent, according to experimental data (Panayotov, 1987). The economic effect of the introduction of new wheat varieties during the period ranges from 31,302,000 leva to 36,519,000 leva.

The dynamics of the total economic effect of introduction of new varieties vary for different years of the period. The rate of economic effect is characterized periodically by sharp drops as a result of the economic losses from introduction of new varieties during various years.

The economic effect of the introduction of new varieties shows different dynamics, share of total size, and absolute level during the different years of potential realization and for the period as a whole. Only as an exception do the changes and the levels of these indices coincide with the indices for production volume by variety.

The total effect of 37.5 percent of the new varieties is negative for the period of introduction as a whole. The economic effect of the introduction of four varieties (13 percent of the number of varieties) at the same time amounts to 88 percent of its total quantity for the period (i.e., real economic profit from improving the variety structure during the period has been realized for only 13.2 percent of the total area under new varieties).

The current level of efficiency of research costs of total variety selection during the period is 3.33 leva/lv, 3.83 leva/lv for soft wheat and 0.76 leva/lv for hard wheat. This indicates the return on total expenditure on selection when introducing new varieties in the year of introduction (for less than four months). During the first five years of the period, the level of

efficiency of expenditure is higher, 0.76 leva for total expenditure and 0.77 leva for soft wheat selection. Increased biological and economic production potential is therefore achieved by increased investment of public research funds in variety selection. Production efficiency dynamics during the period arose through increased investment in science per unit of additional economic effect.

Table 1—Economic Effect of New Wheat Varieties Introduction in Bulgaria

New varieties	1976–80	1981–85	1986–89	1976–89
	<i>Thousand leva</i>			
Wheat:	12,491	-9,034	43,035	46,492
Positive effect	21,679	15,359	45,125	82,163
Negative effect	9,188	24,393	2,090	35,671
Strong wheat:	5,191	173,000	-2,616	3,749
Positive effect	5,191	289,000	6	6,487
Negative effect	0	116,000	2,622	2,738
Hard wheat:	0	654,000	1,275	1,929
Positive effect	0	654,000	1,275	1,929
New varieties total:	17,682	-7,207	41,695	52,169
Positive effect	26,870	17,302	46,407	90,578
Negative effect	9,188	24,509	4,712	38,409

The additional economic effect per unit of cultivated land in terms of realization of the economic potential of new varieties is 1.19 leva/dka. This indicates an increase in quantity of 330 percent, compared to the first five years of the period. It also means that the introduction of variety selection has brought about increased efficiency in the use of land resources during the period.

The economic effect of every research worker employed in the field of research in variety selection has increased to 1,169,000 leva and 223,000 leva, respectively, during the period. It has increased compared to the first five-year period by 145 percent and 140 percent, respectively. Thus the increasing efficiency of labour of those employed in this field of research can be expressed in terms of periods required for improving their level of qualifications.

The level of efficiency of fixed assets used in research during the period is 10.94 leva/lv, including, on the basis of their active part, -26.5 leva/lv, an increase of 227 percent and 203 percent, respectively, compared to the first five years. This expresses the increased return on fixed assets in the research field.

During 1976–89, the extent of the economic effect of the introduction of new varieties of wheat amounts to 1.34 percent of the size of the net product of the sub-branch during the period.

Figure 1 expresses the dynamics of the main indices of wheat production efficiency: where *A* is average yield, *B* is labour productivity, *C* is production profitability, and *D* is increased efficiency in the development of the variety structure during the period. *A*, *B*, and *C* vary for

the different years of the period and do not correspond to the dynamics of the economic effect of introduction of new varieties. *D* is due mainly to other wheat production efficiency factors. The direct influence of the economic effects of selection development on the total efficiency level of production is comparatively small.

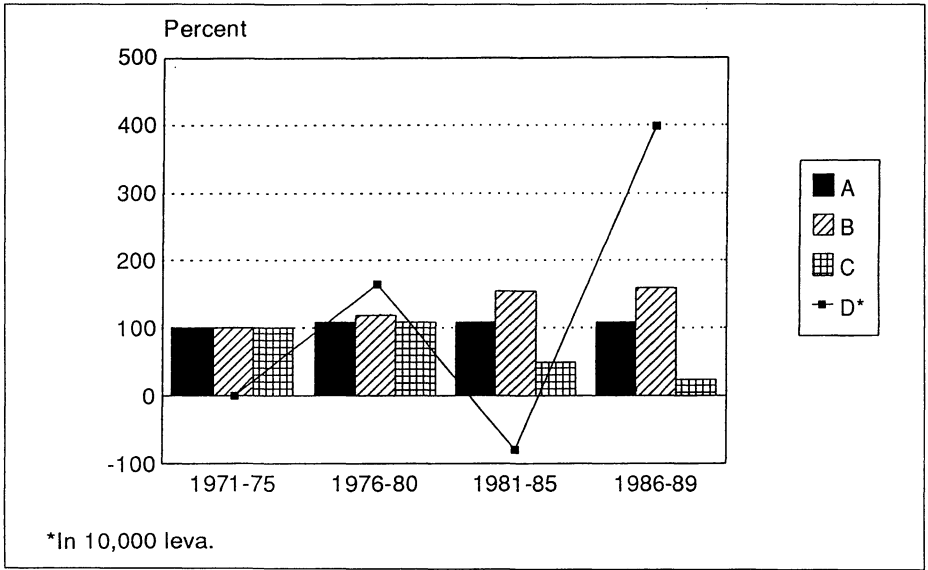


Figure 1—Efficiency of Production and Wheat Selection in Bulgaria

### Note

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**Discussion Opening**—*Katalin Daubner* (Budapest University of Economic Sciences)

I congratulate the authors on their challenging and far-reaching ideas that may provide relevant starting points for discussion. I suggest that the discussion focus on: (1) interlinkages between research, on the one hand, and mass-scale market- production, on the other; (2) effective market demand as a final decisive criterion of research relevancy and its economic efficiency; and (3) a broader approach to and procedures for quantifying research efficiency.

*[This paper was shortened considerably by the editors, and much of the discussion opener's remarks dealt with portions of the paper that were deleted.]*