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# The benefits and limitations of farm equipment supply subsidy: experiences and lessons from Senegal

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**Abstract**

Using household level data collected from cereal based farming systems of Senegal, we examined the prospects and challenges of the Senegalese equipment supply subsidy program. Because of the design of the program—being procured and supplied by the government—we argue that the effect of this program on adoption of improved farm equipment depends on the supply and price benefits as well as the relative importance of ownership to access farm equipment. To empirically support this argument, we assessed the benefits of the subsidy in creating markets and reducing prices and its effectiveness in motivating farmers to use modern farm equipment. Our analyses indeed revealed that though the number of farmers benefited from the subsidy is small, the program has significantly improved the adoption of farm equipment drawn by animals mainly due to its market creation benefit. This has been further confirmed by the qualitative response of farmers who appreciated the quality of the equipment being supplied by the program. However, the effect of subsidy on machinery use is insignificant as it doesn't provide support to those farmers who primary depend on rental services. The price advantage created by the subsidy program is not as such significant either. Farm equipment purchased from the program and the open market appear to have closely similar prices.

Keywords: *Farm mechanization, Input supply subsidy, Adoption of technology, Senegal*

# Introduction

Enhancing farm mechanization is recognized as one of the priority agenda for accelerating African agricultural growth and transformation (Mamo, 2018). However, the strategy to enhance the adoption and utilization of modern farm equipment is yet less clear and controversial. Farm mechanization requires extensive public interventions ranging from structural transformation to direct public support in the form of building skills, facilitating supplies and services, and providing financial supports (Diao et al., 2016). In Tanzania, the Government had facilitated the adoption of 2-wheel tractors under the District Agricultural Development Programs (DADPs), and the Agricultural Inputs Trust Fund (AGITF). The Government of Tanzania had also removed import duties on those machineries to stimulate their demand (Diao et al., 2016). The same study indicated that in Ethiopia, about three-quarters of the total 2-wheel tractors in use were imported by a parastatal. In countries such as Kenya and Zimbabwe where there is no or little intervention of government, the number of 2-wheel tractors in use was very limited (Kahan and Jaleta 2015). In Ghana, a project called ADVANCE (Agricultural Development and Value Chain Enhancement) was implemented to increase adoption of agricultural technology (e.g., hybrid seed, mechanization, climate-smart practices, etc.). To promote farm mechanization, ADVANCE supported 255 service providers with machinery, requiring small down payments from farmers (Diao et al., 2016).

Regarding farm mechanization subsidies, Benin et al. (2013) had presented the Ghanaian's Agricultural Mechanization Service Centers (AMSECs). The main target of the program was to increase agricultural productivity and production by facilitating farm mechanization through services providers across the country. The AMSEC program created credit facilities for private-sector companies to acquire tractors with matching implements at a subsidized price and interest rate. In Senegal, as part of the *Senegalese Agricultural Acceleration Program (PRACAS), the government* subsidizes huge amount of money to enhance the uptakes of modern farm equipment by smallholder farmers. The program purchases improved equipment and sells to farmers or farmers group at a subsidized price. For example, in 2015/2016 season in which 14,835 harvested crop units was produced, about 11,500 single-row seed drills, 2,185 hoes and 1,150 plows were distributed for a total of 3,011,590,100 CFA with a subsidy of 70 % of the supplier price. The State of Senegal mobilizes for subsidy of agricultural equipment. In general, 5 billion CFA were devoted to the acquisition of agricultural equipment in 2015 (IPAR 2015).

Despite the growing public investments on farm mechanization, the effectiveness of these investment in reaching smallholders and motivating them to use improved technologies is not sufficiently known. The literature on equipment subsidy is quite thick and postulates mixed empirical evidences regarding its effectiveness as well as impact on productivity and market distortion. Benin et al. (2013) found that the program was not a success since 73 percent of communities surveyed were not satisfied by the mechanization services. In terms of change in land acreage, a 21 percent increase of mechanized area was observed.

The objective of this paper is to explore the prospects and challenges of enhancing farm mechanization by studying the benefits and limitation of the Senegalese equipment subsidy program. We defined the Senegalese equipment supply subsidy program as a type of input subsidy in which the government not only subsidizes price but also involves in the procurement and distribution of equipment to farmers to access through purchase. Because of the design of the program—being procured and supplied by the government—we argue that the program generates supply and price benefits. The supply benefit includes market (demand) creation through demonstration of new and quality products and enhancing

local availability. The price benefit includes price reduction that would increase affordability to smallholder farmers, though it may cause market distortion effect as well. These two benefits together create incentives for farmers to adopt modern and new farm equipment. However, the effect depends on the way farmers access equipment services. In Senegal, farmers access equipment services either through ownership (by owning the equipment) or through rental services. The subsidy program creates benefits to those who access equipment through purchase. Therefore, the effect of the program depends on the relative importance of ownership in accessing a farm equipment.

To empirically test all the above possibilities, we first estimated the market creation effect using trends of market share and the price reduction effect using comparison of purchase and subsidized prices. Then, we estimated the number of producers benefited from the subsidy, the effect of subsidy on probability of adopting different groups of equipment and the perception of farmers on equipment subsidy. It is our hope that this helps to improve the design and implementation of the program as well as to generate evidence on the possibility and challenges of enhancing farm mechanization through supply-based subsidy program as a lesson to other African countries which are aiming to accelerate agricultural transformation. Besides, the paper contributes to the wider body of literature on input subsidy as a strategy to transform smallholding agriculture in Africa.

The rest of the paper is organized as follows. Next to this introduction section, we present the Senegalese agricultural mechanization policy throughout its history. Then, we describe the sources and type of data used to estimate the models presented in the subsequent fourth section, which presents the strategy followed to estimate the benefits of the program and its effect on farm mechanization adoption. The fifth section present and discusses the results of the study. It covers the coverage and distribution of the program, trends of the market share, the price advantage, the program effect on farm mechanization use and the perception of farmers on the subsidy. Finally, the paper summarizes the major findings and concluding remarks.

## Senegalese agricultural mechanization policy

In the aftermath of independence, the State of Senegal launches its Agricultural Program (PA) setting out the contours of rural development. To achieve the objectives of the agricultural program, the State has emphasized the access of farmers to factors of production (equipment, seeds, fertilizers, agricultural credits, etc.) (Dansokho, 2000). This involves setting up a system that facilitates production with the introduction of inputs and agricultural equipment through credit. This facilitation system is based on an institutional framework for setting up agricultural inputs and equipment, as well as popularizing modern farming methods. Thus, several institutions were created to support agricultural development; the following were more directly involved in mechanization: the National Office for Cooperation and Assistance for Development (ONCAD), created in 1966, was responsible for the distribution of spare parts and agricultural equipment; the National Society for Development and Land Exploitation of the Delta, the Senegal River and the Senegal and Faleme River Valleys (SAED), created in 1965 following the abolition of the Autonomous Organization of the Delta (1960 -1965), was responsible for promoting mechanized intensive rice cultivation; the Senegalese Industrial Company of Agricultural Equipment Trade (SISCOMA), in charge of providing the rural world with the agricultural equipment, the policies have put emphasis on the assembly of national companies of manufacture or assembly of agricultural equipment (CTA, 1997 );

the Senegalese Institute for Agricultural Research (ISRA), created in 1975, is in charge of introducing, adapting or developing technical innovations for rural producers.

The PA has allowed for a massive shift from manual family farming to family farming based on harnessed culture and the use of improved inputs (Faye, 2005). Indeed, this program has made mechanization a strategic focus. It also allowed the implementation of many projects and favored the peasant management of agricultural equipment. This program, with a strong subsidy system has introduced the agricultural equipment at the level of producers. Between 1960 and 1980, the PA distributed 964,651 equipment for a total value of CFAF 17 billion, of which CFAF 15 billion was payable by producers and CFAF 2 billion covered by state subsidies.

Towards the end of the 1970s, a serious agricultural crisis marked Senegal, in spite of the productivism policies carried out on the national territory. Factors such as the droughts of 1969-1973, the prolonged drop in prices of agricultural raw materials in the 1970s and the oil shock of 1972 may explain this situation of Senegalese agriculture. Faced with a strong internal and external financial imbalance, development partners are becoming reluctant to finance Senegal. Structural adjustment is thus an unavoidable measure and the policies leading to it must have started in 1979 with the abolition of the agricultural program (PA). The economic and social recovery program was signed the same year with the IMF (Dieng and Gueye, 2005). Thus, the NPA presents the new orientations of the agricultural sector as part of the national adjustment policy.

Adjustment policies were based mainly on the withdrawal of the state "less state, better state". A reduction in public spending on the removal and restructuring of public services are the levers on which to support the consolidation of the country's public finances. The mechanization sector has felt the effects of adjustment policies with the disengagement of the state, SAED is gradually withdrawing from motorization to give way to the private sector. In harnessed culture, State withdrawal is total in the Groundnut Basin, but it is limited in Eastern Senegal by SODEFITEX and in Lower Casamance by the Intermediate and Integrated Project of Agricultural Development of Lower Casamance (PIDAC) (ISRA, 1987).

In terms of taxation, taxes are increased for all equipment, except for development projects where they are exempt or referenced at nominal prices. The equipment manufactured by SISMAR is taxed at 35% on average when imported materials are 32% for tractors, 68% for spare parts, 94% for fuel. These taxes can also explain the problem of spare parts supply and maintenance during this period. Indeed, most Japanese, Chinese, Korean, Italian, French etc. used mainly in rice is abandoned at the end of the projects that introduced them (CIRAD, 1988).

At the end of the adjustment period, Senegalese agriculture is still struggling to resume the path of growth; as a result, poverty is growing more and more. This deterioration in the situation of the agricultural sector continues to weigh heavily on the country's economy, despite all the efforts made by the Government (Dansokho, 2000). The strategic guidelines focus on the intensification and diversification of national agricultural production. This political will is reflected in the commitments contained in the various special programs on which the State put the individual development of the sectors. Some programs like National Rice Self-Sufficiency Program (PNAR) with a target of 1 million tons of rice by 2012, along with obtaining 510 tractors on the Indian line of credit. These tractors are 50% subsidized. The Great Agricultural Offensive for Food and Abundance (GOANA) has also facilitated access to agricultural equipment through significant state subsidies.

The State of Senegal through its program to accelerate the pace of Senegalese agriculture (PRACAS) facilitates access to heavy agricultural equipment (tractors, combines, etc.) by maintaining subsidies from 60 – 70 percent of the purchase price. Bilateral cooperation with India and Brazil is the basis for the introduction of tractors through credit lines. Brazilian credit, for example, amounted to 45 billion CFA francs. These credits allowed the introduction of subsidized tractors up to 60%. Throughout the history of the government intervention into the agricultural sector, the equipment supply subsidy was part and parcel of the major supports provided to farmers though it wasn't specifically designed and formally structured. The program provides new and modern farm equipment at a subsidized price. It was part of the technology introduction program besides fertilizers and improved seeds.

## Data

We used data from a cross-sectional dataset collected in Senegal under the huge and ambitious project called 'Senegal Agricultural Policy Project' (***Project d'Appui aux Politiques Agricoles***, PAPA, in French) funded by USAID under 'Feed the Future'. The PAPA project is implemented by the Senegalese Government and the local experts with a support of researchers from Michigan State University, the International Food Policy Research Institute, and AfricaLead. The project is still on progress, but a large amount of survey data has been already collected along the different value chains. Among other value chains, there are dry cereals (millet, sorghum, maize, fonio, rainfed rice), irrigated rice, horticulture (banana, onions, tomatoes, melons, …), inputs value chains (seeds, fertilizer, farm implements). Data used in this analysis are from the surveys on dry cereals (rainfed agriculture) and irrigated rice.

All the forty-two agricultural departments of Senegal are covered by the dry cereals survey (the country has 45 departments in total). The 2013 census is used to select farmers to be interviewed. The survey sampling design involved two steps. First, between 10 to 36 Enumeration Areas (EAs) were randomly chosen proportionally to their size (total number of farmers) among all EAs in each department. The last step involved random selection of 5 households from each EA. A total of 4, 680 farm households were selected from the 42 departments. However, due to missing values and attrition, the study uses about 4480 of the households.

For the rice survey, the same census is used to draw farm households from the two agroecological zones (Senegal River Valley, and Anambe Valley) which contributed to about 70-75% of the country total rice production. Most farmers in these zones are involved in irrigated rice. The Senegal River Valley (SRV) is the largest zone among the selected zones with about 75% of the production. Therefore, the sampling took that into account by selecting 75% of sample size from SRV, while the other 25% are from the Anambe Valley (AV). The survey sampling design involved two steps. First, Enumeration Areas (EAs) were randomly chosen proportionally to their size (total number of farmers) among all EAs in each agroecological zones (AEZ). The last step involved random selection of 5 households from each EA. A total of 780 farm households across both AEZ were selected. However, due to missing values and attrition, most analyses in this study use 730 of the samples.

The module on farm equipment provides information on agricultural equipment used by farmers during the production season. It clearly identifies equipment, its mode of acquisition, the year of acquisition, and the price. The mode of acquisition of agricultural equipment include heritage, purchase, rental, and gifts. Information on subsidy to agricultural equipment were also collected. Farmers were asked whether they have bought the equipment from the subsidy program or from the open market. In both cases, they were also asked to report the years they bought, the price they paid to the equipment. These variables are used

to look at the prices and market shares over years. Besides the quantitate data, farmers were asked to report their subjective perception related to the price, quality and accessibility of the equipment subsidy program. These data are used to verify the quantitative findings.

## Estimation strategy

Equipment subsidy is supposed to encourage smallholders to use improved and quality agricultural equipment and farm machinery through reducing prices and better market access. However, the effect of subsidy on use of modern farm equipment—defined as improved plowing, cultivation, planting, harvesting and threshing equipment drawn by animals or machines—depends on its relative importance compared to other options and the benefits being created by the program. Farmers obtain modern farm equipment from different sources. They obtain either through rental services or equipment ownership. Ownership could be from purchase or inheritance or donation. Farmers receive subsidy only when they purchase farm equipment. Therefore, the effect of subsidy on adoption of modern farm equipment depends on the relative importance of these sources as well as the benefits created by the subsidy program.

Because of the design of the program, we argue that the program creates two major benefits such as supply and price benefits. The supply benefit includes market creation effect which increases the availability of new and quality equipment in areas where the market is not functioning, and the technology is not yet known. The price benefit includes price reduction that would increase affordability to smallholder farmers, though it may cause market distortion effect as well. These benefits encourage farmers to adopt modern farm equipment, though the ultimate effect depends on the capacity and willingness of the farmers to purchase instead of renting a farm equipment. Therefore, we first measured the benefits created by the program and then we estimated the effect of the program on probability of modern farm equipment adoption.

The market creation (supply) benefit is measured by the trends of the market share of the program. The market share of the program in a particular year is estimated using the following two indicators

$$N_t = \frac{N_{st}}{N_{mt}+N_{st}} \quad (1a)$$

Where $N_t$ is the volume share of the program at time $t$, $N_{st}$ is the total number of modern equipment purchased by the sample farmers from the program, $N_{mt}$ is the total number of modern equipment purchased by the sample farmers from the private market at time (t).

$$V_t = \frac{\sum_{i=1}^{N_{st}} P_{ist}}{\sum_{i=1}^{N_{mt}} P_{imt}} \quad (1b)$$

Where $V_t$ is the value share of the program at time $t$, $P_{ist}$ is the price of equipment $i$ purchased from the subsidy program at year $t$; $P_{imt}$ is the price of an equipment $i$ purchased from the market at year $t$.

By comparing the trends of the two market shares over time, we able to examine the supply benefit in creating markets. If the share declines over time, the program is indeed creating markets.

We also compared equipment prices purchased from the subsidy program and the open market to estimates the price advantage of the program. Since the equipment are purchased in different years and in different quality, the time and quality effects must be controlled to find comparable prices. This is a challenge for tractors and threshers as their number is very few and the qualities are not measured. Since

most of the heavy machines (tractor and combine harvester) are bought from 2005 to 2016, mean comparison could be a reasonable comparison for these machineries. For the other equipment for which we have enough sample size, we regressed the following price equation

$$P_i = \alpha + \rho S_i + \beta E_i + \theta T_i + \sigma R_i + \varepsilon_i \quad (2)$$

Where $P_i$ the price of an equipment $i$ paid by the farmers; $S_i$ is a dummy variable defined as 1 if the equipment is purchased from the subsidy program, 0 if it is purchased from the market. $E_i$ denotes dummy variables for the type of equipment. We considered only animal drawn equipment such as local hoe, western hoe, animal plow, seeder and animal as they have larger number of observations and their prices are close to each other. $T_i$ is the period (group years) the equipment is purchased. The equipment in our sample are bought since 1951 to 2017 and including dummy variable for each year will make our estimation less efficient due to too many explanatory variables. We rather drop the few observations before 1970 and develop 10 years gap dummy variables. Since the equipment prices are less volatile compared to other agricultural inputs, we believe that controlling the ten years price change is reasonable. In addition, we included trend to control for long term trends of price movement. $R_i$ denotes the regional dummies to control for spatial price variations across regions.

Both the market creation and production benefits of the subsidy program are supposed to encourage farmers to use modern farm equipment. The following regression is used to measure the empirical effectiveness of the subsidy program in enhancing the use of modern farm equipment (farm mechanization).

$$Y_i = \alpha + \rho S_i + Z\beta + \epsilon_i \quad (3)$$

Where $Y_i$ denotes the probability of using an equipment or a group of equipment, $S_i$ is a dummy variable defined as 1 if a farmer purchases any equipment from the subsidy program, 0 otherwise. $Z$ includes a vector of farmer specific and regional dummy control variables. The dependent variable $Y_i$ takes different values depending on the number of equipment or equipment group included in the estimation. First, following the theory of sequential machinery adoption (Pingali, Bigot & Binswanger, 1987) we classified agricultural production equipment based on sources of energy as manual, animal and machine. Thus, Y takes one of the three choices as

$$Y_f = \begin{cases} 0; \ if\ the\ farmer\ uses\ only\ maual\ tools \\ 1; \ if\ the\ farmer\ uses\ animal\ drawn\ tools \\ 2; \ if\ the\ farmer\ uses\ machinery \end{cases} \quad (3a)$$

A farmer is defined as machinery user, if he/she uses an equipment operated by an engine for any farm production operation including plowing, cultivation, planting, harvesting or threshing. The equipment under this category are tractors, thresher, and combine harvesters. Similarly, the farmer is defined as animal traction user if he/she uses any animal traction equipment but not any machinery. Animal traction equipment included in this category are local hoe, western hoe, seeders, animal plow etc. If the farmer didn't use any animal traction or machinery equipment, he/she is classified as manual operator. Since the latent variable which is the choice energy source is hierarchical, as high for machinery, medium for animal traction equipment and low for manual equipment, the effect of subsidy on probability of machinery or animal traction use is estimated using ordered Probit model.

Alternatively, we estimated two separate Probit models for binary choices defined as

$$Y_f = \{1\ if\ the\ farmer\ uses\ machinery; 0\ otherwise \quad (3b)$$

$$Y_f = \{1\ if\ the\ farmer\ uses\ animal\ tools;\ 0\ if\ uses\ only\ manual\ tools \quad (3c)$$

This disaggregation is needed to test if the subsidy has asymmetric effect on animal and engine drawn farm equipment. As a final check, we estimated an ordered Probit to test the effect of the subsidy program on use of multiple animal drawn equipment defined as

$$Y_f = \begin{cases} 0\ if\ the\ farmer\ deson'tuse\ any\ animal\ drawn\ eqipemnt \\ 1\ if\ the\ farmer\ uses\ only\ one\ animal\ drawn\ eqipemnt \\ 2\ if\ the\ farmer\ uses\ two\ animal\ drawn\ eqipemnt \\ 3\ if\ the\ farmer\ uses\ three\ or\ above\ animal\ drawn\ eqipemnt \end{cases} \quad (3d)$$

# Results and discussion

## Coverage and distribution of equipment subsidy

Table 1 provides the different indictors used to measure the coverage and distribution of the program using the number of producers benefited from the program and the number of subsidized equipment purchased across the two farming systems. Of the total sample farmers, only 12 percent of them purchased at least one subsidized farm equipment. The percentage of beneficiaries increases to 14 if we consider only those samples who purchase any equipment. This is because subsidy is given only when farmers purchase an equipment. Despite the importance of rents to access machineries, the program excludes producers who depend on renting machines. This could be an important challenge that policy makers have to investigate if the program is aimed at expanding the use of engine operated large-scale farm equipment.

The coverage and size of subsidy significantly varies across farming systems. Farmers in dry cereal producing areas are more likely to receive a subsidy than in irrigated rice producing areas. The number of farmers who purchased more than one subsidized equipment is also higher in dray cereals producing areas (about 36 percent of the beneficiaries) than rice producing areas (about 25 percent of the beneficiaries). However, the maximum number of subsidized equipment purchased by farmers is larger in rice producing areas than in dry cereal producing areas. Since the irrigated rice producing areas purchase high-priced heavy machineries more than the dry cereal producing areas, the total subsidy channeled to the farmers could be larger in irrigated rice producing areas.

**Table 1. The coverage of farm equipment subsidy in Senegal**

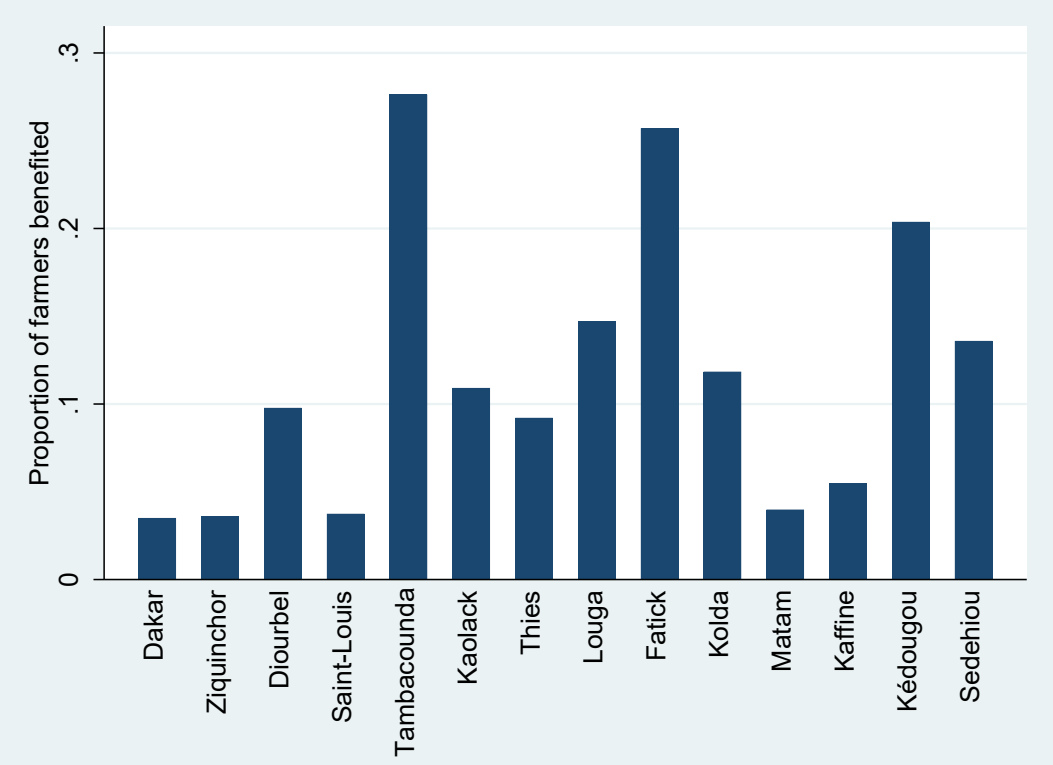
| Percentage of farmers purchased | Total | Irrigated Rice | Dry Cereals |
|---|---|---|---|
| At least one subsidized equipment out of total sample (N=5210) | 11.6 | 8.1 | 12.2 |
| At least one subsidized equipment out of the samples who purchased an equipment (N=4,088) | 14.8 | 9.3 | 15.8 |
| Only one subsidized equipment (N=604) | 65.2 | 74.6 | 64.2 |

| | | | |
|---|---|---|---|
| Two subsidized equipment (N=604) | 22.2 | 11.9 | 23.3 |
| More than two subsidized equipment (N=604) | 12.6 | 13.5 | 12.5 |
| Maximum number of equipment subsidized per farmer | 10 | 6 | 10 |

***Source**: Authors estimation based on the 2017 PAPA irrigated rice and dry cereal surveys*

Figure 1 shows the distribution of farmers benefited from the subsidy program across regions. There seems to be a significant geographic variation of subsidy coverage within the country. The proportion of farmers who bought at least one farm equipment from the program ranges from 4 to 28 percent. The highest coverage was observed in Tambacounda, Fatick and Kedougou and the lowest in Dakar, Ziquinchor, Saint-Louis and Matam. The program seems less important in regions which have better market access than others.

**Figure 1. Percentage of farmers benefited from the subsidy program across regions**



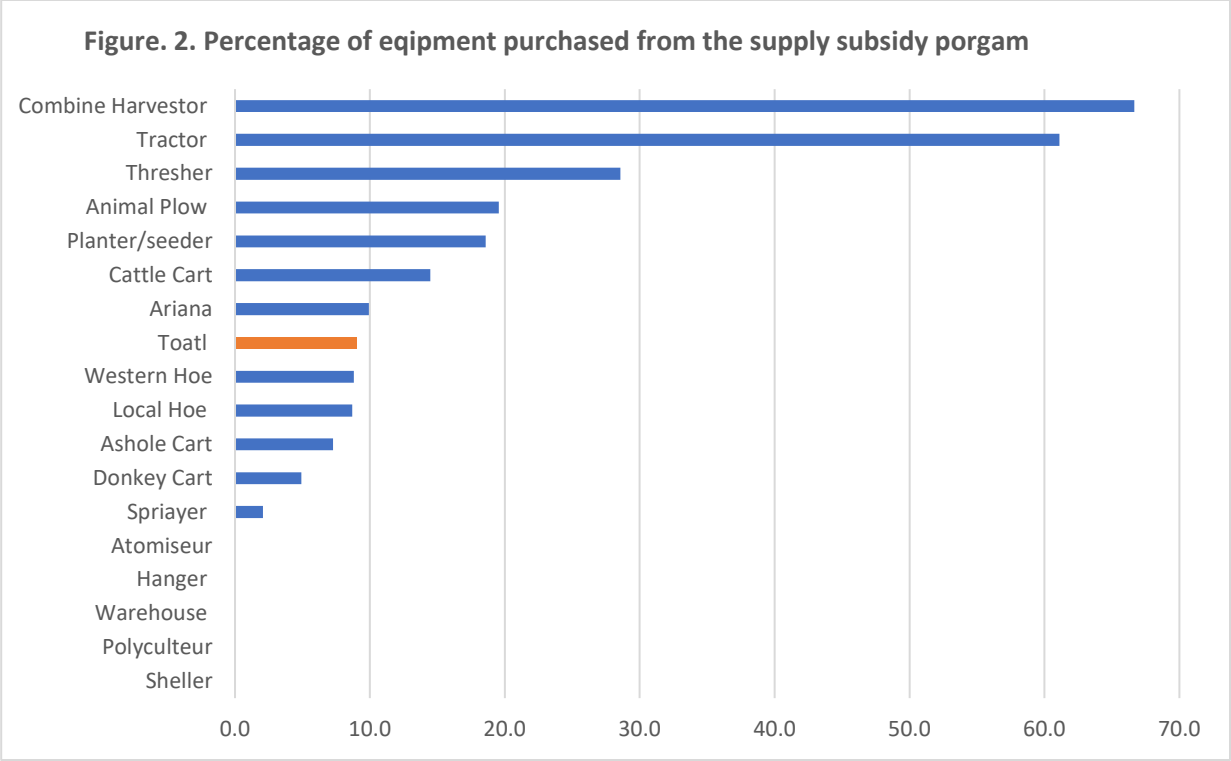

Many of the households who benefited from the equipment subsidy are male headed, educated (at least read and write) and have higher farm size than households who purchased from the market (Table 2). The capacity of the household looks more important than the needs of the households. This raises the concern of efficiency and equity. However, if the program supplies better quality at higher price, the poor households may not afford to purchase. The subsequent sections will explain if that is indeed the case.

**Table 2. Characteristics of sample households benefited from the equipment subsidy program**

| Characteristics | Farmers purchased only from the market | Farmers purchased from the program | Difference |
|---|---|---|---|
| Percentage of female headed households | 8.3 | 4.1 | -4.2 |
| Average age of the household head | 52.8 | 54.6 | 1.8 |
| Percentage of educated household head | 36.8 | 46.4 | 9.6 |
| Average total family size | 9.7 | 11.1 | 1.4 |
| Average total farm size in hectare | 5.0 | 8.2 | 3.2 |

## Market share of the program

Out of the total equipment purchased by our samples about 9 percent of them were from the subsidy program (Figure 2). Thus, the average market share of the program is less than 10 percent. Disaggregation of the market share by type of equipment revealed that the program covers larger machineries more than animal tractions and smaller machines. Of the three combine harvesters purchased in our sample, two of them were supplied by the subsidy program. Similarly, two-third of the tractors owned by the farmers were supplied by the program. The two most important animal drawn farm equipment supplied by the subsidy program are animal plow and planter. Therefore, even if the number of farmers who benefited from the equipment subsidy is small, the equipment being supplied by the state are the expansive ones. This will make the overall volume of the equipment subsidy very substantial at national level. Furthermore, the program seems more important for the introduction of higher level of mechanizations.

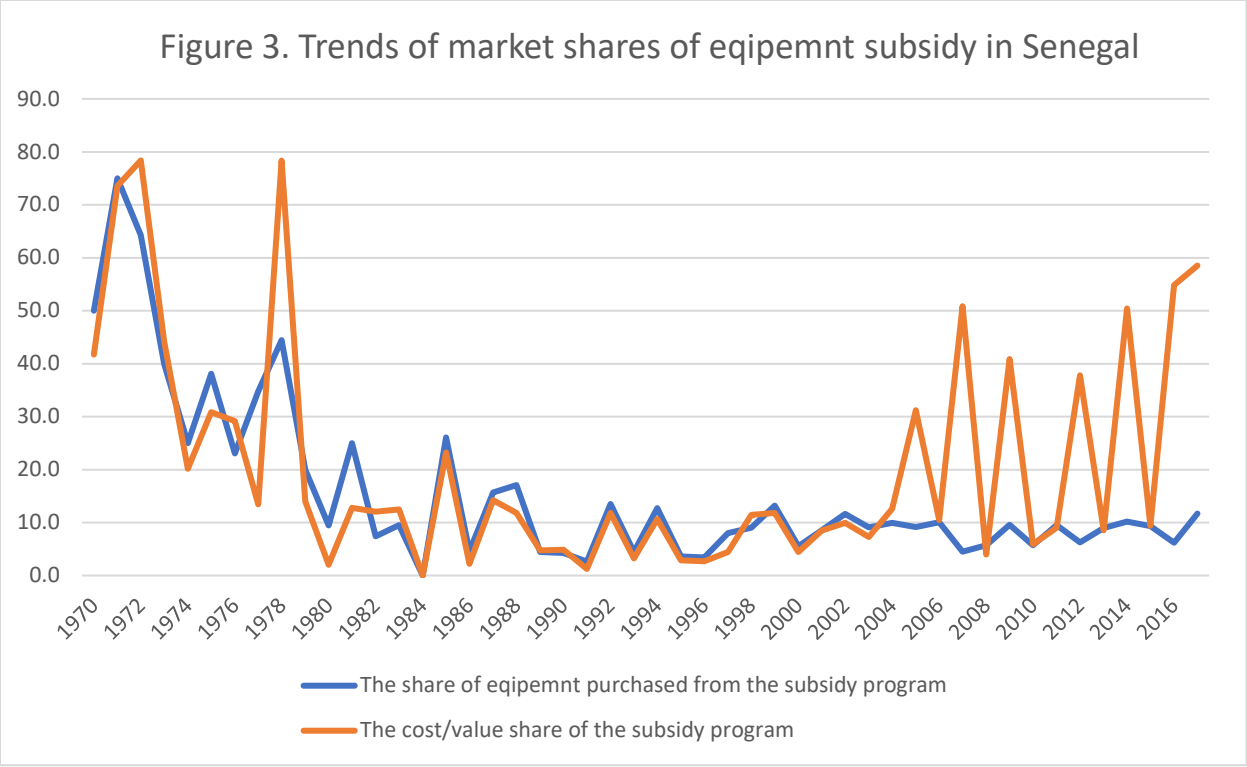



***Source**: Authors estimation based on the 2017 PAPA irrigated rice and dry cereal surveys*

The farm equipment owned by our samples was purchased at different years. Some are as old as 100 years. We traced the share of the government equipment subsidy program across years (Figure 3). The result clearly demonstrates the declining share of equipment purchased from the subsidy program both in terms of number and value. In 1970s about 40% of the equipment were supplied by the government program. This figure has declined to 13% in 1980s and remained below 10% thereafter. The rate of decline is lower in recent years than the years in 1980s and 1990s, more so in 1970s. The same trend has been observed for the share of supply measured by total values of equipment supplied except an increasing trend in value shares in most recent times. In recent times, the value share is not only increasing but also significantly higher than the quantity share.

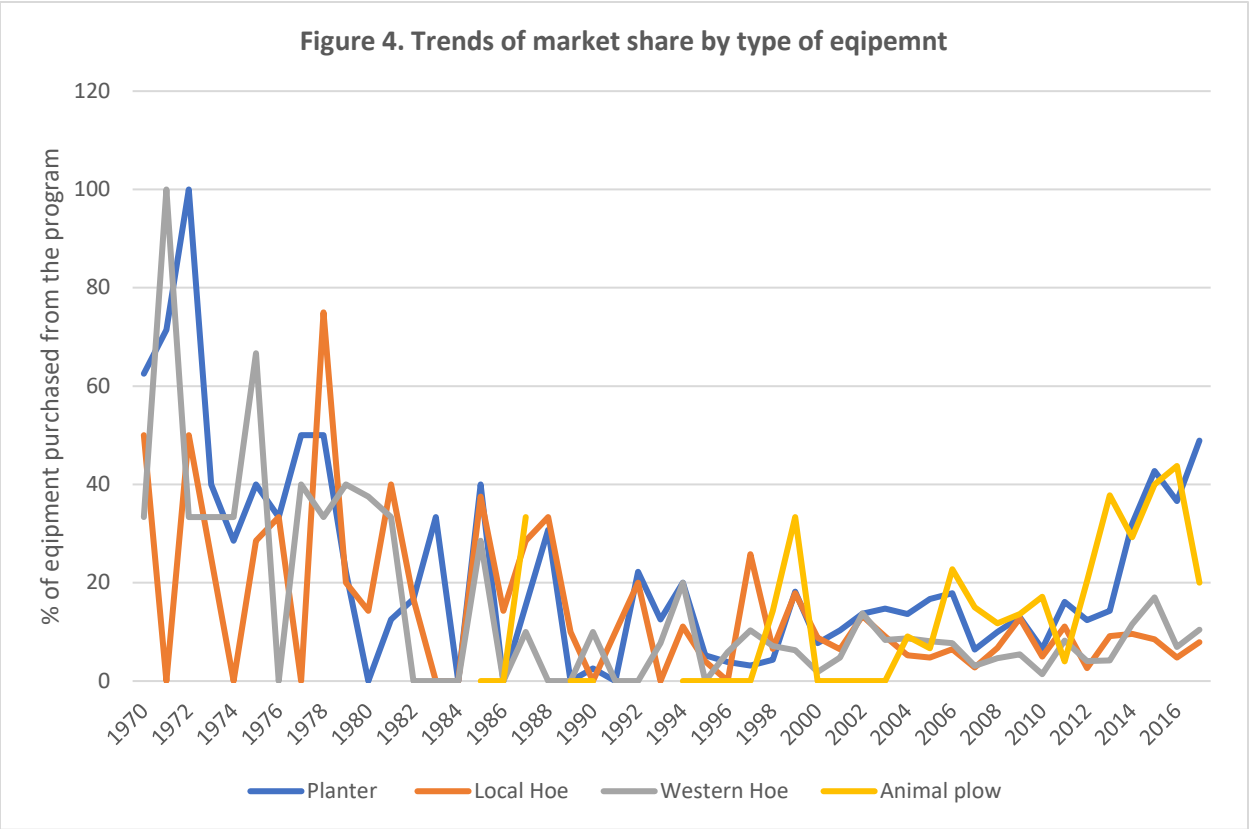
The declining trends may indicate that the government subsidy is not a regular input subsidy per se, rather a technology subsidy to support the introduction of the equipment. Meaning the demonstration and availability effects of the program are creating markets for the private sector. Once the equipment is introduced, farmers are purchasing mainly from the open market as indicated by the increasing share of equipment purchased from the market. Alternatively, it may be explained by the policy change of the government —withdrawing from the support program and leaving the market for the private sector. Both explanations are possible. The slower rate of decline in recent years than the rate of decline in 1970s, and 1980s and 1990s could be associated to policy change. But the declining trends within a decade must be associated to the market creation effect of the program.

The growing and higher value share than the quantity share in recent years must be explained by the high cost of equipment being supplied in recent years. This implies that the program has now shifted to supporting high value machineries. But these machineries are very few and unable to increase the quantity share.




*Note: calculated based on (1a) and (1b)*

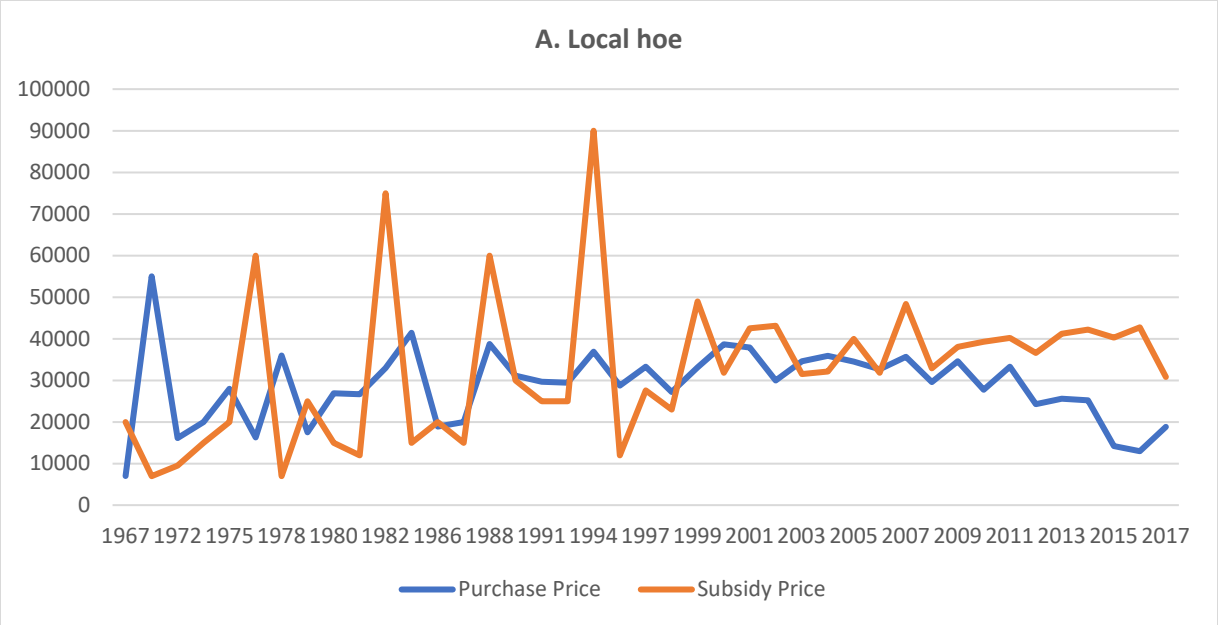
The quantity market shares for selected animal drawn have shown similar trend with total equipment market shares (Figure 4). However, significant difference is observed across equipment types. For planter and western hoe, the figure shows declining trends. The trend for local hoe is almost stable throughout the years except a higher share in 1970s and closely similar rate thereafter. Consistent to our expectation, the market creation effect is higher for planter and western hoe than planter and local hoe. The share of the program is increasing for animal plow and planter since 2010 implying the program has aggressively supplying the equipment and playing a significant role as a marketing agent instead of an extension agent. For these tools, the program seems crowding out the private farm equipment suppliers.

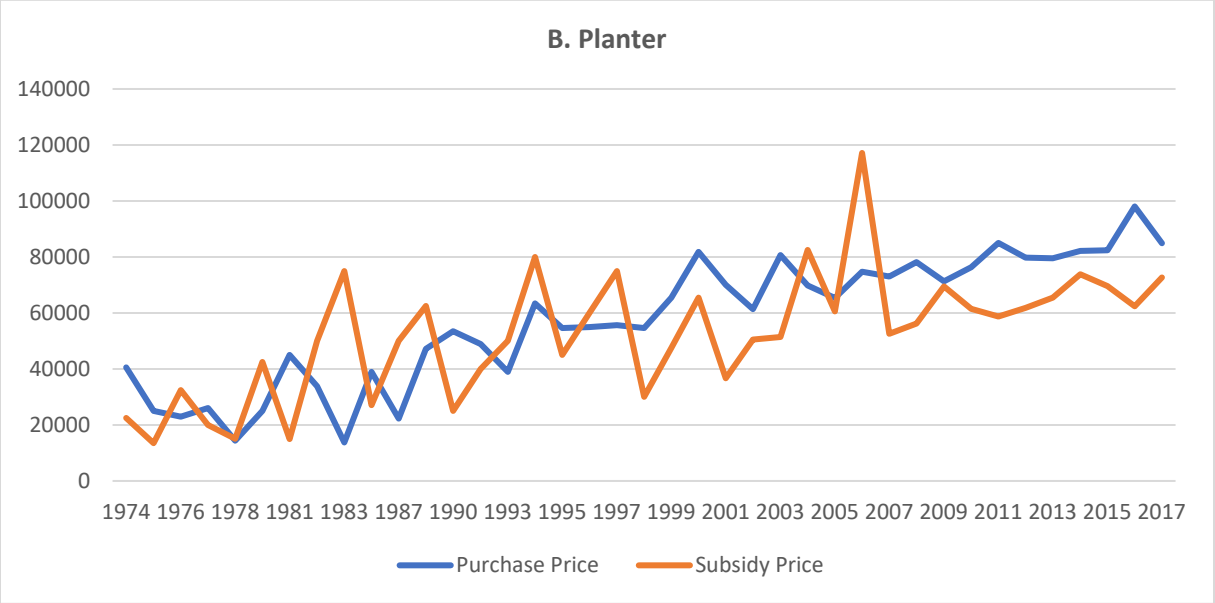



## Price advantage of the equipment subsidy

Figure 5 presents the price trends of selected animal traction equipment for which we have enough samples across years. The most revealing finding is the comparison of prices across time for animal drawn equipment. The price for planter is increasing over time (Figure 5B). The subsidy and market prices were trending very closely until 2008 but then after the subsidy price becomes smaller than the market price. The opposite is true for local hoe whose price has shown modest growth, but the subsidy prices are getting higher than the market prices in recent times. Therefore, the price advantage of the subsidy program is somehow mixed. We conducted a further price comparison analysis using simple regression in which we controlled type of equipment, years and regions as explained by equation (2).

**Figure. 9. Comparison of market and subsidy prices of selected farm equipment in Senegal**




***Source**: Authors estimation based on the 2017 PAPA irrigated rice and dry cereal surveys*

Table 3 reports the results of the mean comparison of subsidy and market prices of all equipment purchased by the farmers since 1970. The variable 'Subsidy' measures the effect of the program on prices, the periods indicated by years are dummy variables to control decadal effect compared to the base 1970-1989, and the regional dummies representing the 14 regions are included but their results are reported here. We also included trend to control long term trends of nominal prices. The comparison is made step-wise to check if the correlation of the subsidy program across years and regions. The result, however, remains consistent across all specifications. On average, the subsidy price is not different from the market price. Therefore, the program has no any significant price advantage. However, this finding must be cautiously interpreted as the quality of the equipment is not controlled. Even if we assume the equipment supplied by the subsidy program are higher quality than the ones supplied by the market—which seems the case as per the qualitative evaluation presented latter—the program has the market creation effect

more than price advantage. If the program has no price effect, it may also imply that it has less price distortion effect unless we believe that domestic market price is already distorted.

**Table 3. The effect of subsidy on equipment price paid by the farmers**

| VARIABLES | Prices paid by the farmers | | | |
|---|---|---|---|---|
| | (2a) | (2b) | (2c) | (2d) |
| Subsidy (1= purchased from the subsidy, 0=from the market) | -0.609 | 1.432 | 1.410 | 0.812 |
| | (2.085) | (2.137) | (2.139) | (2.153) |
| Western hoe | -5.736*** | -4.497** | -4.479** | -2.634 |
| | (2.040) | (2.059) | (2.060) | (2.209) |
| Animal plow | 13.17*** | 12.60*** | 12.62*** | 9.717*** |
| | (3.010) | (3.019) | (3.020) | (3.134) |
| Seeder | 41.83*** | 43.32*** | 43.34*** | 42.29*** |
| | (1.828) | (1.856) | (1.857) | (1.899) |
| Cart | 93.01*** | 93.91*** | 93.92*** | 93.17*** |
| | (1.645) | (1.661) | (1.662) | (1.740) |
| 1980-1989 | | 8.297 | 7.598 | 4.502 |
| | | (5.389) | (5.923) | (5.883) |
| 1990-1999 | | 16.67*** | 15.22** | 9.292 |
| | | (4.831) | (7.017) | (7.010) |
| 2000-2009 | | 25.14*** | 23.00*** | 13.09 |
| | | (4.554) | (8.799) | (8.806) |
| 2010-2017 | | 25.33*** | 22.63** | 12.71 |
| | | (4.496) | (10.51) | (10.50) |
| Trend | | | 0.0707 | 0.292 |
| | | | (0.249) | (0.250) |
| | | | | (1.984) |
| Constant | 27.59*** | 3.798 | -135.9 | 0.229 |
| | (1.193) | (4.572) | (491.3) | (490.4) |
| Observations | 8,562 | 8,425 | 8,425 | 8,425 |
| R-squared | 0.325 | 0.332 | 0.332 | 0.347 |

*Source: based on the 2017 PAPA irrigated rice and dry cereal surveys. Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1;*

## The effect of subsidy on farm mechanization adoption

The ultimate benefit of the subsidy is encouraging smallholder farmers to adopt improved farm equipment. As explained in the previous section, we examined the strength of association (we are not claiming causality as we didn't control other variables that may affect the selection of farmers for subsidy program) between participation in subsidy and the use of machines and animal tractions. As shown in Table 4, we estimated 4 alternative models—specified above as equation 3a, 3b, 3c, and 3d—to ensure the robustness of the estimation as well as to examine the type of equipment for which the subsidy is important using the data from the rice farming system.

Participation in equipment subsidy has shown positive and significant association with farm power transition from manual to animal to machinery. Similarly, it has significant association with the probability

of using improved seeder as well as the probability of using higher number of animal drawn equipment (Table 4). The effect is stronger on number of animal drawn equipment than on farm power transition because of its insignificant effect on the probability of machinery use. A farmer who has received a subsidy has a higher probability of using animal seeder than a farmer who hasn't receive a subsidy. The effect of subsidy increases as the number of animal drawn equipment used by a framer increase. This implies that the subsidy not only encourages the use of a farm equipment but also the use of complementary equipment at the same time. The strong and significant effect of subsidy on probability of animal equipment adoption is explained by the fact that many of the producers who use animal drawn equipment obtain through purchase.

Participation in equipment subsidy has no effect on the use of farm machinery. This shall be explained by the relative importance of ownership to access machinery equipment. Since most of the producers who use machines obtain through rents—instead of purchase—the effect of subsidy on machinery use is insignificant. Many studies suggest that machinery rental services were the most viable and relevant for smallholder farmers (Houssou et al, 2015; Sharma et al.1998; Singh et al., 2013). These services were already very popular in Asian regions, but that was not the case in Sub-Saharan Africa region (FAO, 2003, 2006). In Ghana, machinery hiring services were in great expansion and most farm machinery users were mechanized through rental services (World Food Programme 2009; Akramov and Malek 2012). Similarly, most farmers that used tractors in Botswana and Mozambique did not own but hired their implements (Cunguara and Darhofer; 2011). Therefore, the finding of this study suggests that the subsidy impact on machinery is being limited by its allocation only to the purchase of the equipment rather than subsidizing the hiring services. This would systematically discourage the use of heavy machines through rental services in long run. Furthermore, the subsidy may widen the rural income inequality as the better-off able to purchase heavy machines while the poor depends on rental services. Based on our policy review in section 2, the subsidy covers only 60-70% of the equipment price. Farmers must obtain the rest 30-40 of the heavily machines (tractors, combine harvesters) price from other sources and it is beyond the capacity of smallholders.

**Table 4. The effect of subsidy on use of farm mechanization**

| | (3a) | (3b) | (3c) | (3d) |
|---|---|---|---|---|
| **VARIABLES** | **Mechanization** *(1=manual, 2=animal, 3=machine)* | **Use of machine** *(1=yes, 0=no)* | **Animal drawn Planter** *(1=yes, 0=No)* | **Number of Animal drawn equipment** *(plow, seeder and hoe) (0=none, 1= 1 ,2= 2, 3=3 or 4)* |
| Sex of household head (0= male, 1=Female) | -0.465** | -0.356 | -0.380 | -0.560*** |
| | (0.218) | (0.283) | (0.247) | (0.177) |
| Age household head | 0.0133** | 0.0137** | 0.00773 | 0.00278 |
| | (0.00543) | (0.00652) | (0.006) | (0.00443) |
| Household head (1= literate, 0=illiterate) | 0.0847 | 0.154 | -0.144 | -0.206* |
| | (0.137) | (0.169) | (0.155) | (0.113) |
| Number of fulltime family labor | -0.0304 | -0.0297 | 0.0463 | 0.0185 |
| | (0.0333) | (0.0412) | (0.0368) | (0.0285) |
| Off-farm cash income (millions CFA) | 0.509** | 0.0677*** | 0.153 | 0.0408 |
| | (0.221) | (0.239) | (0.234) | (0.195) |
| Total agricultural land size in ha | 0.0449*** | 0.0490*** | -0.00682 | -0.0117* |
| | (0.0130) | (0.0139) | (0.00753) | (0.00705) |

| | | | | |
|---|---|---|---|---|
| Tambacounda | 1.660*** | 1.273*** | 0.324 | 0.310 |
| | (0.304) | (0.408) | (0.378) | (0.263) |
| Kolda | 1.887*** | 1.444*** | 1.867*** | 2.251*** |
| | (0.204) | (0.260) | (0.193) | (0.139) |
| Matam | 1.821*** | 1.727*** | 0.138 | 0.838*** |
| | (0.227) | (0.285) | (0.281) | (0.159) |
| **Access to subsidy (1=yes, 0=No)** | **0.497*** ** | **0.225** | **0.892*** ** | **0.975*** ** |
| | (0.191) | (0.236) | (0.226) | -0.560*** |
| Observations | 729 | 729 | 729 | 729 |

***Source**: Authors estimation based on the 2017 PAPA irrigated rice and dry cereal surveys*

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. The first and fourth models are estimated using ordered probit and the second and the third models are estimated using probit estimation.

## Perception of farmers on farm equipment subsidy

Farmers were asked on their perception about the level of subsidized price, quality and quantity of equipment supplied through subsidy and the mode of distribution. The result indicated a very clear difference among producers in irrigated rice and dry cereals producing areas on the level of subsidized price (Table 5). While more than half of irrigated rice producers perceive the subsidized price is too expensive, more than 70 percent of dry cereals producers perceive the price is affordable. In both areas, most farmers (as much as three-quarter of them) believe that the quality of equipment supplied through subsidy are better than the equipment available in the market. However, two-third of the samples reported the inadequacy of the subsidized equipment supply. Similarly, the inaccessibility of the current distribution mechanization is the other problem reported by most of the farmers.

**Table 5: Household's perceptions on subsidy on agricultural equipment**

| Variables | Responses | Irrigated rice | Dry cereals |
|---|---|---|---|
| Subsidized price level | Too expensive | 54.3 | 5.7 |
| | Expensive | 19.6 | 23.3 |
| | Affordable price | 26.1 | 71.0 |
| Equipment quality | No difference | 17.4 | 13.9 |
| | Better than that available on market | 58.7 | 75.1 |
| | Less than that available on market | 23.9 | 11.0 |
| Quantity of equipment available | Enough | 2.2 | 4.9 |
| | Quite Enough | 32.6 | 29.0 |
| | Not enough | 65.2 | 66.1 |
| Mode of distribution | Not accessible to all | 54.3 | 81.6 |
| | Accessible to all | 45.7 | 18.4 |

***Source**: Authors estimation based on the 2017 PAPA irrigated rice and dry cereal survey*

## Conclusion

Though substantial amount of money is being channeled to equipment subsidy, the number of farmers benefited from the equipment subsidy program are few. Only 12 percent of our sample producers purchased at least one subsidized price. We also observed less significant difference between market and

subsidized equipment prices. The effect of subsidy on the adoption of farm machinery appears to be insignificant since subsidy is given to farmers who only purchase an equipment and excludes who depend on rental services. However, the subsidy has significantly helped farmers to adopt improved farm equipment drawn by animals. Moreover, many farmers apricate the quality of equipment being supplied by the subsidy program.

The current subsidy program appears to benefit those who purchase an equipment. More importantly, significant number of farmers complain about the quantity and accessibility of subsidized equipment. A mechanism must be sought to support farmers for rental services since renting is the dominant way of accessing engine-powered equipment. Alternatively, the introduction of small-scale engine-powered equipment may help farmers to benefit from the subsidy program as well as to expand farm mechanization. The pricing of farm equipment for subsidy needs the attention of the program planners and implementers to optimize the benefits of the program. Both the objective price comparison and the subjective farmers' evaluation indicate the expensiveness of subsidized equipment.

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