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REPLACEMENT ADOPTION: A CASE OF VARIETAL SUBSTITUTION AMONG FARMERS ADOPTING SAWAH RICE PRODUCTION TECHNOLOGY IN NIGERIA AND GHANA.

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ABSTRACT

This paper examined the incidence of replacement adoption through varietal substitution among farmers adopting Sawah-ecotechnology rice production technology in Nigeria and Ghana. A simple random sampling was used to select 80 farmers in Nigeria and 70 farmers in Ghana. Data were collected in June 2010 with a structured questionnaire in villages where Sawah rice production technology had been introduced. In Nigeria, 30 % of the farmers practice varietal substitution with the use of WITA 3, while in Ghana 40% practice varietal substitution using jasmine and sycamore. The results from the Probit model showed that significant variables include yield (t = 4.12) participation in on farm demonstration (t = 2.77) contact with Sawah agent (t = -1.93), varietal adaptability (t = -2.29), market price (t = 2.50), lodging proneness (t = 2.45), age (t = -3.35) and farming experience (t = 2.49) in Nigeria and Ghana. It therefore implies that the issues of varietal substitution must be viewed within the prevailing socio-economic and farming system milieu of farmers in order to enhance continuous adoption and sustained profit from Sawah technology

1. INTRODUCTION

Accelerating agricultural growth remains one of the most urgent objectives facing policy makers in less developed countries, where agricultural productivity is low, population growth rates are high and the ability to import food is severely constrained. Although international trade and food aid may alleviate short-term imbalances between the growth in demand and supply of food, it is likely that long-term food security will only be achieved by sharp increases in domestic food production (Dadi, Burton & Ozanne 2004). An understanding of the determinants of technological change in agriculture is therefore vital to the design of policies that will alleviate poverty and chronic food insecurity. The Green Revolution that transformed agricultural production and the food security situation in areas of south and East Asia has not in general been replicated in sub-Saharan Africa. Otsuka & Kalirajan (2006) reported that the main prerequisites (use of improved varieties, fertilizer use, and strong national extension system) of green revolution in Asia have been ineffective in the transferability of the process to Africa.

It is believed that an effective way to increase productivity is broad-based adoption of new farming technologies (Minten & Barrett, 2008). Adoption of improved technologies will

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improve food security and reduce poverty if barriers to their continued use are overcome (Oladele, 2005). As recognized by Doss (2003 and 2006), one way of improving agricultural productivity, in particular and rural livelihood in general, is through the introduction of improved agricultural technologies to farmers. Doss, Mwangi, Verkuijl & Groote, (2003) also opined that adoption of improved technologies is an important means to increase the productivity of small holder agriculture in Africa, thereby fostering economic growth and improved wellbeing for millions of the poor households. Technological change in agricultural inputs which is fundamental to the transformation of rural Africa, has not been fully embraced by smallholder farmers in the region. It has long been recognized that the continuous use of traditional, low yielding crop varieties is a major cause of low crop productivity, but correctly identifying the factors that prevent smallholder farmers from adopting improved, high yielding crop varieties remains a challenge.

1.1 Adoption study paradigms

The importance of farmers' adoption of agricultural technology has long been of interest to agricultural extensionists and economists. Several parameters have been identified as influencing the adoption behaviour of farmers from qualitative and quantitative models for the exploration of the subject. Social scientists investigating farmers' adoption behaviour have accumulated considerable evidence showing that demographic variables, technology characteristics, information sources, knowledge, awareness, attitude, and group influence affect adoption behaviour. A wide range of economic, social, physical, and technical aspect of farming influences adoption of agricultural production technology. Adoption studies in Europe (Charmala & Hossain, 1996; Frank 1997), in Asia (Sharma & Pradhed, 1996, Patel, Senoria, & Nahetkar, 1996) and in Africa (Abdelmagid & Hassan, 1996; Adesina & Baidu-Forson, 1995) have identified farm and technology specific factors, institutional, policy variables, and environmental factors to explain the patterns and intensity of adoption.

Ogunsumi & Ewuola (2005) also reported that socio-economic status of farmers is positively and strongly related to adoption. This report implied that the higher the socio-economic status, the higher the tendency to adopt innovation. These evidences over decades of adoption studies have led to the categorization of adoption behaviour into innovators, early adopters, early majority, late majority and laggard and that the adoption behaviour of any agricultural technology would follow a normal distribution curve in a given social system (Rogers, 2003). Zhang & Owiredu (2007) reported that the total amount of land owned and/or cultivated by farmers, and use of government extension services by the farmers have a significant positive influence on the adoption of plantation establishment in Ghana. Manyong & Houndékon (2000) noted that security over land was among the factors that significantly affect the adoption of technology, with a high marginal effect on the probability of adoption.

Duration analysis was used to examine the impact of time-varying and time-invariant variables on the speed of adoption of fertilizer and herbicide by smallholder farmers and the estimated models suggest that economic incentives were the most important determinants of the time farmers waited before adopting new technologies (Dadi *et al* 2004).

Langyinto & Mekuria (2008) examined the influence of neighbourhood effect on the adoption of improved agricultural technologies in developing agriculture. The potential for neighbourhood effects among farmers in a community is high because, those using a new technology may pass on information about it to others (Holloway, Lucila, & Lapar, 2007). Spatial heterogeneity may also result from agro-ecological differences. In other words, as farmers make technological choices, they are influenced by the behaviour of neighbouring farmers or by agro-ecological characteristics. In developing countries, adoption models that include location variables control for spatial heterogeneity due to agro-ecological differences (Doss, 2005) but neighbourhood effects are largely unaccounted for. As noted by Holloway *et al.* (2007), neglecting information about neighbourhood effects may lead the researcher to understate the influence of individual or household characteristics on economic outcomes,

1.2 Emergence of adoption studies terminologies

Due to the volume of research on adoption behaviour and a very long period of these researches several terminologies have been associated with the adoption concept. Adoption of innovations refers to the decision to apply an innovation and to continue to use it [Rogers 2003]. This is closely followed by the main options of active rejection, which occurs when farmers consider adoption of innovation (including its trial) but then deciding not to adopt it and passive rejection (also called non-adoption), which consists of never really considering the use of the innovation. The concept of sustainable adoption was defined as the degree to which an innovation continues to be used over time after a diffusion program ends (Rogers 2003). This is closely related to the term continued adoption which is the persistent use of an innovation. Ogunsumi & Ewuola (2005); Oladele & Kareem (2003) analyzed sustained adoption among farmers and the concept was operationalised as the maintenance of the intensity of adoption by farmers. Dadi *et al*. (2004) used duration analysis to capture the dynamic aspects of adoption of agricultural technologies b explaining the probability of adoption rather than the time it takes an individual to adopt.

Wetengere (2010) reported that the concept of selective adoption exists among farmers and it was described as the selection of some parts of a technology or modification and re-invention may be options too. Farmers' choice whether to adopt an entire package of a recommended technology or just some parts of a technology is influenced by availability of household resources; the degree to which the technology is appropriate for the farmer's farming environment; farmers' characteristics and farmers' objective for undertaking the activity (particularly spread risk). Adoption rent has been described as the economic benefits which accrue to early adopters. It is also depicted as a factor influencing adoption and the adopter category to which a farmer belongs.

Tsegaye, Aredo, La Rovere, Mwangi, Mwabu, & Tesfahun (2008) noted that partial adoption is the practice of the using the least involving components of a technology, which could be any of the individual components alone. Also partial adoption was described as when farmers can adopt those parts of an innovation that they like or that are consistent with other farming objectives and that under the traditional model of adoption, partial adoption will inevitably lead to complete adoption. Hossain, Manik, & Bazlul Mustafi (2006) indicated that adoption gap is the difference between potential and actual adoption rate, which can be reduced through an effective dissemination project. Masuki, Tumbo, Baltazary, Hatibu & Rwehumbiza (2007), Akinola, Arega, Adeyemo, Sanogo, Olanrewaju, Nwoke, Nzigaheba, & Diels, (2007) Arega (2009) reported that adoption intensity refers to the number of technologies practiced by the same farmer. The intensity of adoption of different technologies is measured by a variable that represents the breadth of technology use within a particular stage of production. Saha *et al*. (1994) recognized that producers' adoption intensity is conditional on their knowledge of the new technology and on their decision to adopt. Similarly IFAD (2010) determined the intensity of adoption as the amount of modern inputs used per unit area, while Tsegaye *et al* 2008 measured the intensity of adoption in the order of the number of the components of the technology adopted by a farmer. Most adoption studies were based and analyzed on ex post framework which is the analysis of factors that determined actual adoption. Ex post adoption rely on actual, as opposed to potential, adoption events, and enable researchers to determine which characteristics are statistically associated with adoption (Mercer 2004). Sirrine, Shennan & Sirrine (2010) depict ex ante adoption as the potential feasibility, profitability, and acceptability of an innovation.

Currently an important component of the innovation decision- making process which is receiving research attention is the discontinued adoption behaviour which is the decision to reject an innovation after having previously adopted it. Oladele (2005) reported two types of discontinuance which can be replacement discontinuance that is rejecting an idea in order to adopt a better one that supersedes it or disenchantment discontinuance when a decision to reject an idea as a result of dissatisfaction with its performance. Alexander, Fernandez-Cornejo, & Goodhue (2002) and Darr & Chern (2002) described discontinuance among farmers who previously adopted Genetically Modified crops by Ohio farmers as dis-adopters. Ogunfiditimi (1993), and Kolawole, Farinde, & Alao (2003) examined "abandoned adoption" to describe discontinued use of previously adopted innovation and reported the varying degrees of discontinuance among farmers in Ekiti state Nigeria to be immediate, gradual and rapid based on the nature of innovation and farmers situation. Tura, Dejene, Tsegaye, La Rovere, Mwangi & Mwabu (2009) using a bivariate Probit model indicated that, dis-adoption is largely determined by the asset portfolio of farmers and by the structure of markets for credit, labour and by seeds. Also Carletto *et al.* (1999); Neill and Lee, (2001); Oladele, (2005); Aklilu & Graaf, (2007); and An (2008) have investigated reasons why farmers dis-adopt technologies. Other studies, which are mostly from western hemisphere, have little to say about problems of discontinuation of adoption in the context of rural Africa, where structural and institutional constraints are likely to adversely affect poor farmers' ability to continue using already adopted technology. With respect to the rice production technology which is the focus of this paper, Fu *et al,* (2009) examined farmers adoption and propensity to abandoned adoption of Sawah-based rice farming in the inland valley of central Nigeria

1.3 Introduction of Sawah rice production technology

Due to the existing potential which has not been translated to actual production in of Nigeria and Ghana in rice production Sawah rice production technology was introduced after preliminary research work on the characterization of lowlands and on-farm demonstration based on collaboration among Japan International Cooperation Agency (JICA), Shimane Univ. Kinki University Japan, IITA Crop Research Institute of Ghana (CRI), Soil Research Institute of Ghana (SRI) and Inland Valley Rice Development Project (IVRDP) of African Development Bank (ADB), Watershed Initiative in Nigeria (2001), a Non Governmental Organization, Agricultural Development Project, Ministry of Agriculture, Niger State and National Cereals Research Institute (NCRI). The main goal of Sawah projects in West Africa by Japanese institutions is the development of sustainable production systems of the whole watershed, which allows intensification and diversification of the lowland production system and stabilizing improved production systems on the upland. Fashola, Oladele, Aliyu & Wakatsuki, (2006) noted that the Sawah system offers the best option for overcoming rice production constraints in Nigeria because of the utilization of the inland valleys which are reported to be high in fertility and enhances water management for rice production through pudding and the inlet and outlet canals for irrigation and drainage. Asubonteng (2001) reported that Sawah technique leads to high yields and sustainable production irrespective of fertilizer use. Sawah rice production technology involves an eco-technology which is a manmade environment with levelled and bunded rice fields with inlet and outlet connecting irrigation and drainage. The components of the technology include:

- Bunding
- Ploughing using power tiller, flooding
- Flooding(10cm water level)
- Puddling with power tiller leveling,
- Smoothing using power tiller
- Transplanting
- Use of improved variety (WITA 4)
- Fertilizer application

The combination of all these components is shown in Figure 1 against the usual practice among farmers on lowlands.

Fig. 1. Lowlands before and after sawah in Nigeria.

For the purpose of this study, it is assumed that farmers make adoption decision based upon utility consideration (Batz, Peter & Janssen, 1999). Comparing various technologies that are used, farmers will adopt a technology if its utility exceeds the utility of others. The utility of an activity is measured by its contribution to household food and income security. Household resources are allocated across various activities based on their contribution to household food and income security. When a technology is introduced in a given area, the choices available to farmers are not just adoption or rejection as often portrayed by many researchers. The occurrence of varietal replacement among rice farmers particularly in Asian countries has been related to economic issues of yield income, risk reducing and increased production. Bangladeshi farmers have been replacing modern varieties MV, particularly, if they are of shorter maturity and the yield is higher compared with the existing ones which led to positive productivity and profitability Hossain, Lewis, Manik, & Chowdhury (2003). The low replacement of MV in Bangladesh is often the result of such factors as a weak research-extension linkage, less effective public sector extension system, and the absence of a good seed market in Bangladesh (Hossain, Janaiah, Husain, & Naher, 2001). Hossain *et al* (2006) reported that replacement of NERICA rice variety led to adoption gap creating a difference between the potential and actual adoption rate and thus reducing the impact of the adoption of the variety in terms of yield-increasing, cost reducing, quality-enhancing, risk-reducing, environmental-protection increasing, and shelf-life enhancing. Adoption over time makes innovation institutionalized and the distinct quality of the innovation to be fading. As innovation diffuses into the social system, its variants begin to evolve from adopter to adopter. This variation is conceptualized as re-invention, which is described as the degree to which an innovation is changed or modified by users in the process of adoption. This is against the premise that farmers are innovative and are actively experimenting based on indigenous knowledge through improvisation. The generalizations underlying re-inventions states that re-invention occurs at the implementation stage for many innovations and for many adopter; a higher degree of re-invention leads to a faster rate of adoption of an innovation (Backer, 2000) and a higher degree of sustainability of an innovation. The degree of re-invention is to identify the number of elements in each implementation of an innovation that are similar to, or different from, the "main-line" or "core" version of the innovation, such as that promoted by the change agency. Most innovations can be broken down into their constituent elements, which can then be used to measure the degree of re-invention from a core configuration. The core elements of an innovation consist of the features that are responsible for its effectiveness (Kelly, Anton, Wayne, Otto-Salaj, Timothy, Hackl, Heckman, Holtgrave, & Rompa, 2000).

Some reasons for re-invention lie in the innovation itself, while others involve the individual or organization adopting the new idea. These are that innovations that are relatively more complex and difficult to understand are more likely to be re-invented; re-invention can occur owing to an adopter's lack of detailed knowledge about the innovation, such as when there is relatively little direct contact between the adopter and change agents or previous adopters (Kelly *et al.,* 2000) and re-invention sometimes happens due to ignorance and inadequate learning. Other reasons include the fact that innovation that is a general concept or a tool with many possible applications is more likely to be re-invented; innovation that were implemented in order to solve a wide range of users' problems is more likely to be re-invented; local pride of ownership of an innovation may also be a cause of re-invention; change agency influencing clients to modify or adapt an innovation; adaptation of innovation to the structure of the organization that is adopting it (Mahajan, Muller & Wind , 2000) and re-invention may be because late adopters profit from the experiences gained by earlier adopters. It is important to note that the volume of researches on discontinued adoption notwithstanding, these studies do not differentiate between replacement discontinuance and disenchantment discontinuance. This paper is focusing on replacement discontinuance adoption and argues that while the term may ordinarily appear as negative owing to the pro-innovation bias that pervades much adoption inquiry, and the implicit assumption in studies of a linear sequence of the first three stages in the innovation- decision process: knowledge, persuasion, and decision. In some cases, the actual sequence of stages might be knowledge, decision, and persuasion. Replacement adoption is conceptualized in this study as the change of a component of a technology package in order to improve the overall efficiency of the whole technology. In this case of Sawah rice production technology, the incidence of replacement adoption among farmers is the practice of varietal substitution from the recommended WITA 4 to WITA3 or Jasmine varieties. The objective of the study was to determine the incidence of replacement adoption through varietal substitution among farmers adopting Sawah-ecotechnology rice production technology in Nigeria and Ghana. Specifically the study examined the socio-economic characteristics, land tenure status and farm characteristics of farmers adopting Sawah-ecotechnology rice production.

2. METHODOLOGY

The study was carried out in Nigeria and Ghana, and covered 12 fields in Nigeria with 80 farmers while in Ghana 11 fields in 5 villages (Adugyama, Biemso No 1, Biemso No2, Fediyeya & Attakrom) were covered with 70 farmers. The field locations in Ghana are in the Ahafo Ano South district. Ghana is located on West Africa's Gulf of Guinea only a few degrees north of the Equator on Latitude: 5 degrees, 36 minutes north, Longitude: 0 degrees, 10 minutes east. This area, known as the "Ashanti," produces most of the country's cocoa, minerals, and timber. The climate is tropical with two distinct rainy seasons in the south-May-June and August-September; in the north, the rainy seasons tend to merge. The choice was necessitated by the fact that all Sawah development projects have concentrated on the Ahafo Ano South districts. In Nigeria, most of the fields covered are in Bida area of Niger state, while a village (Pampaida) was covered in Kaduna state and Akure in Ondo state. Villages covered in Bida area include Shabamaliki, Ejeti, Ekapagi, Nasarafu, Etsuzegi and Gadza. Bida, has a clayey loamy, sandy soil, under the guinea savannah ecology and is 137 m above sea level and lies on longitude 6°01'E and latitude 9°06'N in Niger State of Nigeria. The sampling frame is the list of farmers adopting Sawah-ecotechnology rice production from which a simple random sampling was used to select 80 farmers in Nigeria and 70 farmers in Ghana. Data were collected in June 2010 in all the villages where Sawah rice production technology had been introduced and adopters of Sawah technology were interviewed. A structured questionnaire with a reliability coefficient of 0.85 was used to elicit information on socio-economic characteristics, land tenure status and farm characteristics. Descriptive statistics was used to describe the data while Probit model was used to analyze the use of varietal replacement with particular reference to the effects on the spread of the technology.

A Probit model is appropriate when the dependent variable to be evaluated is dichotomous (Ameniya, 1981 and Maddala, 1983). The relationship between the probability of a variable Pi and its determinants q is given as:

$$Pi = \beta qi + \mu i \quad \ldots\ldots\ldots (1)$$

Where Pi=1 for Xi>Z; i=1, 2 ......, n; qi is a vector of explanatory variables and β is the vector of parameters. The Probit model computes the maximum likelihood estimator of β given the non-linear probability distribution of the random error μi.

When the dependent variable takes more than two values and these two values have a natural ordering, the use of an ordered Probit is indicated and estimated using the maximum likelihood method.

In the Probit model the discrete dependent variable Y is a rough categorization of a continuous, but unobserved variable Y^*. If Y^* could be directly observed then standard regression methods would be used (such as assuming that Y^* is a linear function of some independent variables, for example:

$$Y^* = \beta_1 X_{1i} + \ldots\ldots \beta_j X_{ji} + ui \quad \ldots\ldots\ldots (2)$$

In this study, Y^* is the practice of varietal replacement which is used as a proxy for Y^*.

The actual model specification is: practice of varietal replacement
= $\beta_0 + \beta_1$Yield + $\beta_2$participation in on farm demonstration (OFDP) + β_3Contact with Sawah agent + β_4 variety adaptability + β_5Market price + $\beta_6$proneness to lodging+ $\beta_7$land tenure + β_8 farmers' age + β_9 group membership + β_{10}household size + β_{11}farming experience + *u*

The dependent variable Pi is a dichotomous variable which is 1 when a farmer uses varietal replacement and 0 if otherwise. The explanatory variables are: X_1 = yields in t/ha, X_2

dummy variable for participation in on farm demonstrations (Yes = 1, No = 0); X_3 = dummy variable for contact with Sawah agents (Yes = 1, No = 0); X_4= dummy variable for variety adaptability (adaptable = 1, Not adaptable = 0); X_5 = market price of the rice in Naira; X_6 = dummy variable for proneness to lodging (prone = 1, not prone = 0), X_7 = dummy variable for land tenure (owned = 1, others = 0); X_8 = Age in years, X_9 = dummy variable for group membership (member =1, others = 0); X_{10} = Household size as number of persons dummy, and X_{11} = farming experience in years

3. RESULTS AND DISCUSSION

Table 1 shows the socio-economic characteristics of farmers adopting Sawah rice production technology in Nigeria and Ghana. The table shows that in Nigeria, majority of the farmers are about 42 years of age having quranic form of education, belonging to at least one farmers group and have been farming for about 13 years. The land tenure system is predominantly through inheritance. The mean score for household size among farmers was 4.6 and only 30 % of the farmers practice varietal substitution with the use of WITA 3. In Ghana, the mean age is about 45 years with most farmers having attended primary school, and belonging to farmers groups. There is an average of 17 years in terms of farming experience and land tenure system was based on secured renting and 40% practice varietal substitution using jasmine and sycamore

Table 1: Socio-economic characteristics of respondents

Socio-economic/farming characteristics	**Description**	
	Nigeria	**Ghana**
Age	Mean = 41.96	Mean = 44.70
Educational level	Predominantly Quranic	Predominantly primary school
Membership of Farmer group	Predominantly members	Predominantly members
Farming experience	Mean = 13 years	Mean = 17 years
Land tenure system	Predominantly Inheritance	Predominantly secured rent
Household size	Mean = 4.6	Mean = 7.2
Varietal substitution	30% with WITA 3	40% with Jasmine and Sycamore

The results from the Probit model in Table 2 showed that the coefficients for 8 variables were significant in Nigeria and 9 variables Ghana. In Nigeria, these are yield (t = 4.12) participation in on farm demonstration (t = 2.77) contact with Sawah agent (t = -1.93), varietal adaptability (t = -2.29), market price (t = 2.50), lodging proneness (t = 2.45), age (t = -3.35) and farming experience (t = 2.49). A similar trend of results was observed in Ghana with the significant variables including yield (t = 7.20) participation in on farm demonstration (t = 2.32) contact with s/ member Sawah agent (t = -2.57), varietal adaptability (t = -9.63), market price (t = 2.85), lodging proneness (t = 5.00), age (t = -2.45) group membership (t = -4.24) and farming experience (t = 4.04). The sign for each coefficient is consistent with the expectation; that is, the probability of practicing varietal substitution increases if yield increases, participation in on-farm demonstrations, high market price for the variety used for substitution, and long farming experience. The inverse relationship explains the effect of contact with Sawah agent, variety's adaptability and age to the practice of varietal substitution. The negative sign on the coefficients implies that insecure tenure is somewhat of a constraint to the practice of varietal substitution. Contact with Sawah agent, variety's adaptability and age however were inversely related to the adoption of Sawah technology in both countries, which shows that as farmers had less contact with Sawah staff, poor adaptability of the recommended variety and the older the farmers become the probability of practicing varietal substitution will decrease. This may be connected with the strenuous demand of the activities.

Table 2: Parameter estimates from Probit regression model

Variables	Nigeria Coeff./S.E.	Ghana Coeff./S.E
Yield	4.12	7.20
Participation in on-farm demonstration	2.77	2.32
Contact with Sawah agent	-1.93	-2.57
Variety's adaptability	-2.29	-9.63
Market price	2.50	2.85
Lodging proneness	2.45	5.00
Land tenure	1.34	-0.082
Age	-3.35	-2.45
Group membership	-0.73	-4.24
Household size	-0.80	-0.016
Farming experience	2.49	4.04
Intercept	-2.15	-18.00
Pearson Goodness-of-Fit Chi Square	110.02	301.22
Df	78	68
P	0.00	0.000

4. CONCLUSION

The study has shown that replacement adoption exist among farmers with a view of improving the overall efficiency of the whole technology package, with at least 30% of the farmers practicing varietal substitution in Nigeria and Ghana. In both countries the determinant of varietal substitution include yield (t = 4.12) participation in on farm demonstration (t = 2.77) contact with Sawah agent (t = -1.93), varietal adaptability (t = -2.29), market price (t = 2.50), lodging proneness (t = 2.45), age (t = -3.35) and farming experience (t = 2.49). The pattern of practicing varietal substitution is skewed toward farmers that have long farming experience and were willing to explore the high market price of the variety that were used as substitutes. Similarly important socioeconomic variables affecting varietal substitution were age and group membership. It therefore implies that the issues of varietal substitution must be view within the prevailing socio-economic and farming system milieu of farmers in order to enhance continuous adoption and sustained profit from Sawah technology.

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